STRUCTURE OF

SIX FARM INPUT INDUSTRIES

- Petroleum
- Farm Machinery and Equipment
- Fertilizers
- Chemical Pesticides
- Livestock Feeds
- Farm Credit

ERS-357
U.S. DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE

FOREWORD

This report was prepared by staff members of the Farm Production Economics Division, Economic Research Service, W.B. Sundquist, Director. John F. Gale and Ronald L. Mighell were primarily responsible for assembling the six major portions of the report. Dean E. McKee, formerly Chief, and Velmar W. Davis, Chief, Production Resources Branch, supplied leadership and guidance. William B. Harper, Bureau of Mines, U.S. Department of the Interior; John N. Mahan, Agricultural Stabilization and Conservation Service, J. Warren Mather, Farmer Cooperative Service, Walter Scholl, Agricultural Research Service (retired), and Harold H. Shepard, Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture; George H. Seferovich, Implement & Tractor Publications, Inc.; and Galen Winter, Manufacturers Representative, contributed both information and time to the preparation of this report. Ray A. Goldberg, Graduate School of Business Administration, Harvard University, aided in planning the project.

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Washington, D.C. January 1968

SUMMARY

This report consists of a description of six different industries--petroleum, machinery, fertilizer, pesticides, feed, and credit--all of which in some way supply the farmer with the inputs necessary for efficient production. In these six farm input industries are found some of the most basic changes in modern American agriculture. Yet, this side of the farm economy has been relatively neglected in analyses.

This report seeks principally to examine the general structure of the six industries as they are changing. Those treated provide some of the largest items of farm cash expenditure, but by no means all. We do not, for example, look closely at land and labor, nor at the industries which supply farmers with many other material and service inputs.

Farm consumption makes up only about 7 percent of total sales in the petroleum industry--5 percent for fuels and 2 percent for petrochemicals. One-third of all crude oil is produced by six major oil companies, the rest by 32 companies.

The fertilizer industry has recently experienced rapid growth, stimulated by new technology. The stress of expansion has breached many traditional channels of distribution and brought new economies. Of the three basic raw materials, phosphate rock and potash are handled by only a small number of firms while nitrogen production is more widely distributed. The changes in the fertilizer industry have resulted in relatively lower prices and increased consumption.

The use of chemical pesticides in agriculture has also undergone recent and rapid escalation. The industry has relatively few basic producers for most individual items. But there are many items, farmers use only 40 percent of the total output, and producers and formulators have many other interests.

The farm machinery and equipment industry is one of the older farm supply industries. It grew out of the farmer-blacksmith-craftsman stage of a century ago and in many ways resembles the automobile industry today. Farm machinery companies have many of the same problems that the automobile companies have--national distribution, maintenance of supply parts and service, and so on. But unlike automobile manufacturers, they do not have as large a mass market, and they are dealing with a shrinking, rather than an expanding, number of customers. They are also burdened with a greater variety of supporting machines and with a large overlay of used equipment. Much farm equipment has a longer life than an automobile, and obsolescence may be a more difficult problem.

Several of the important farm machinery companies are divisions of, or are otherwise related to, larger corporations. For some of them, the farm market represents but a small part of a total business concerned mainly with altogether different products.

The livestock-feed business (feed grains, concentrates, and formula feeds that move in commercial channels) is also a long-established industry. In 1965, it accounted for about 60 percent of the total feed grains consumed by livestock and poultry. Feed grains consumed on the farms where they are produced still make up a large part of the total. On-site farm mixing is an increasingly strong competitive factor which helps to keep manufactured feed prices in line. Large national feed firms are important suppliers in many areas. Regional farmer cooperatives and their local affiliates handle about 20 percent of the total that farmers buy through commercial channels. The growth of bulk handling and such innovations as smaller "satellite" mills tend to decentralize operations within the firm, which at the same time retains the economies of central management.

The credit industry is a well-organized system which provides the farmer with a number of conventional credit arrangements, but whether the system is entirely adequate for financing the dynamic changes underway is not clear. New developments in supervised credit and in contract production suggest that there may be further changes. The sheer increase in the size of the investment in capital goods required on today's commercial farms means that financial management of farms needs to take on new dimensions.

Human ingenuity and technology have so modified the characteristics of nearly all resources that the time-honored classifications of land, labor, and capital are no longer adequate. These terms still serve as convenient reference points for some purposes, but technical and social engineering have given us a great variety of inputs and of ways of using them. Even land, once regarded as a rigidly fixed resource, can often be treated as a variable input.

These possibilities in use of land and other farm resources mean that arrangements for supplying inputs are much more flexible than formerly. But this general advantage is not without its costs, as reflected in the prices of inputs or in the terms of the arrangements.

These notes sketch something of the structure of six of the farm input industries. Neither exhaustive nor fully definitive, they do suggest the general outline of the changing and increasingly complex commercial world in which the farmer now buys his inputs.

STRUCTURE OF SIX FARM INPUT INDUSTRIES

Petroleum, Farm Machinery and Equipment, Fertilizers, Chemical Pesticides, Livestock Feeds, Farm Credit

By Farm Production Economics Division
Economic Research Service

INTRODUCTION

This report should provide a better understanding of the complexity of the industrial network that now underlies so much of modern farming. For those not fully acquainted with the farm input industries, the information will help put industry in perspective with agriculture.

No major industry has changed more than farming in the last quarter century. Farmers are continually adjusting to new technology. And it is this adjustment which has meant a significant shift from farm-produced to industry-produced inputs. The farm, no longer the originating center for food and fiber production, is a halfway station in a long chain of production stages that begins with the farm input industries, passes through the farm, and goes on through further processing and transportation to the consumer.

The index numbers of quantities of farm inputs in table 1 show that inputs purchased have risen dramatically--about 65 percent since 1940. Those not purchased have fallen by about 40 percent. Total inputs have risen only moderately. The significant change is in the composition of inputs and the related increase in productivity.

The drop in labor inputs is explained first by the increased use of mechanical power. The number of tractors on farms tripled from 1940 to 1966. Their available power capacity rose even more as individual power units became larger. Mechanical power has been adapted to most farm tasks.

Innovating farmers with laborsaving inputs often find themselves underemployed. As a result, many have enlarged their farms, so that the number of farms has declined from a high of more than 6 million in 1935 to slightly more than 3 million in 1966. In these years, the number of farm operators and unpaid family workers decreased from 10 million to below 4 million. Average employment of hired workers declined from 2.9 million to less than 1.5 million. Altogether, some 7.4 million farmworkers left farming, a 58-percent decline in 30 years.

In 1966, farm production expenses totaled about $33 billion. Nearly half of the total was spent for six items--petroleum products, machinery, fertilizer, pesticides, feed, and interest on the farm debt (table 2). These leading expenses are mainly from the nonfarm sectors and are visible signs of commercial farming. They are going to affect farmers' decisions on production (output) even more in the future. Not only are the volume and quality of the inputs themselves important, but also the management services that frequently accompany them.

Table 1.--Index numbers of farm inputs, total and by major category, United States, selected years, 1940-66

(1957-59=100)

Year	Total inputs			Farm labor	Farm real estate	Mechanical power and machinery	Fertilizer and liming materials	Feed, seed, and livestock purchases 3/	Miscellaneous
	All	Nonpurchased 1/	Purchased 2/						
1940	97	142	72	192	92	42	28	45	73
1945	99	140	76	177	88	54	45	72	76
1950	101	119	91	142	97	86	68	72	85
1955	102	111	97	120	100	99	90	86	94
1960	101	96	103	92	100	100	110	109	106
1965	103	85	113	74	100	101	164	124	124
1966 4/	105	81	119	70	99	103	185	130	128

1/ Includes operator and unpaid family labor, and operator-owned real estate and other capital inputs.
2/ Includes all inputs other than nonpurchased inputs.
3/ Includes only that portion of feed, seed, and livestock purchases represented by the values in constant dollars of goods and services added to the original farm production of these items.
4/ Preliminary.

Source: Econ. Res. Serv., "Changes in Farm Production and Efficiency, 1967," U.S. Dept. Agr., Statis. Bul. 233, Revised June 1967.

Table 2.--Selected farm production expenses, United States, 1950 and annual 1960-66 1/

Year	Petroleum fuel and oil	Tractors, other machinery and equipment 2/	Fertilizers	Pesticides	Purchased feed	Interest paid	Total selected expenses	Selected as a percentage of total production expenses
	Million dollars	Million dollars	Million dollars	Million dollars	Million dollars	Million dollars	Million dollars	Percent
1950	1,192	2,187	868	179	3,283	598	8,307	42.8
1960	1,481	1,965	1,208	287	4,911	1,352	11,204	42.7
1961	1,471	2,023	1,264	345	5,108	1,441	11,652	43.1
1962	1,470	2,116	1,363	395	5,562	1,594	12,500	43.8
1963	1,464	2,402	1,446	435	6,115	1,789	13,651	46.2
1964	1,502	2,637	1,571	484	5,700	1,967	13,861	47.2
1965	1,530	3,052	1,618	564	5,760	2,172	14,696	47.6
1966	1,562	3,694	1,771	619	6,345	2,457	16,448	49.4

1/ Excludes Alaska and Hawaii.
2/ Excludes automobiles and motortrucks.

Source: Econ. Res. Serv., "Farm Income Situation," FIS-207, July 1967. Estimate for pesticides provided by Farm Income Branch, Econ. and Statis. Anal. Div., Econ. Res. Serv.

NOTE 1--PETROLEUM

by

George C. Allen and Theodore R. Eichers 1/

The Setting--Agriculture and Petroleum

In little more than 100 years, the petroleum industry has grown into a supplier of three-fourths the Nation's energy needs. Before the shift from draft-animals to internal combustion engines and the widespread use of tractors, farmers bought little fuel for farm power. Today, nearly all power used by farmers depends on petroleum and its derivatives.

In 1966, these energy fuels made up nearly 7 percent of all current farm operating expenses, or $1.5 billion (2). 2/ At the same time, the farm market accounted for only 5 percent of total petroleum sales. It is likely that this market share will decline further as farmers convert to power units that are more efficient, use lower cost fuels, or both, while other sectors of the economy continue to increase petroleum consumption.

However, the interest of the petroleum industry in agriculture extends far beyond supplying farmers with fuel. The industry also owns the basic sources of natural gas, a major raw material in producing ammonia for fertilizer, and accounts for nearly 40 percent of the synthetic anhydrous ammonia production capacity. Furthermore, a number of petroleum firms have diversified into fertilizer mining and manufacturing operations in recent years. Petroleum hydrocarbons are also the base for many of the present-day agricultural pesticides, and for urea, an important nitrogen product used for fertilizer and feed. Thus, a knowledge of the petroleum industry, its organization, and operations leads to a better understanding of other farm input industries.

Structure of the Petroleum Industry

At the refining and marketing stages, the petroleum industry is composed mainly of large companies (table 1). Standard Oil Company (N.J.) ranked third in sales among all industrial firms in the United States in 1965. Four other petroleum companies, each having sales of over $2.5 billion, were among the first 15 business firms in the country in that year. The petroleum industry gives direct employment to more than 1,200,000 people, and indirectly affects everyone. In 10 years, 1953-64, it spent $60 billion for facilities to find, produce, transport, and market its products. The industry is growing in both size and complexity. The value of refinery shipments alone increased from $8.4 billion in 1950 to $18.3 billion in 1964 (11).

1/ George C. Allen and Theodore R. Eichers are members of the Production Resources Branch, Farm Production Economics Division, Economic Research Service.

2/ Underscored numbers in parentheses refer to Selected References, page 13.

Table 1.--The 20 largest petroleum firms, United States, ranked by 1965 operating income,1/ compared with 1963 and 1964

Rank 1965	Corporation	Operating income		
		1965	1964	1963
		Million dollars	Million dollars	Million dollars
1	Standard Oil (New Jersey)	$11,472	$10,815	$10,266
2	Socony Mobil Oil	4,908	4,499	4,352
3	Texaco	3,779	3,574	3,416
4	Gulf Oil	3,385	3,174	2,978
5	Shell Oil	2,562	2,332	2,129
6	Standard Oil (Indiana)	2,472	2,318	2,267
7	Standard Oil of California	2,243	2,286	2,203
8	Phillips Petroleum	1,451	1,342	1,275
9	Continental Oil	1,450	1,268	1,147
10	Sinclair Oil	1,276	1,187	1,212
11	Cities Service	1,201	1,170	1,214
12	Sun Oil	925	839	844
13	Tidewater Oil	711	680	665
14	Atlantic Richfield	688	636	624
15	Signal Oil & Gas	671	605	377
16	Pure Oil	2/637	605	587
17	Union Oil of California	2/597	568	502
18	Marathon Oil	549	496	466
19	Standard Oil (Ohio)	531	483	446
20	Sunray DX Oil	483	464	484
	Total	$41,991	$39,341	$37,454

1/ Including service and rental revenues.
2/ Merged July 1965--on merged basis ranks 11th; figures allocated for 1965 based on 1964 sales volume as independent corporations.

Source: (3).

In its producing operations, the oil industry brings to its customers a wide variety of compounds, both liquid and gas. Initial separation at oilfields produces three main revenue lines: crude oil, natural gas, and natural-gas liquids (NGL). Natural-gas liquids consist of natural gasoline plus a number of fluids (under pressure) grouped under the name of liquefied petroleum gases or LPG. These include the familiar bottled gases, butane, and propane. In addition, NGLs include gasoline, jet fuel, diesel oil from NG processing plants with fractionating equipment, and lesser substances of interest to the petrochemical industry.

Chemicals derived from petroleum and its products account for 70 percent of the production value of all chemicals (11). Despite this high proportion of the value of all chemicals, less than 2 percent of the physical volume of all petroleum gas and crude oil is used for this purpose. Expansion for petrochemicals is anticipated at a rate more than 3 times that for the total national economy, because of demands created by new products based on research in petrochemical technology (11). Sales of petrochemicals to farmers account for only about 2 percent of the total sales of the petroleum industry.

Most major oil companies are highly integrated, some more than others. Geographically, the petroleum industry is concentrated and fragmented. Seven States produce 85 percent of the oil and 90 percent of the gas brought to the surface.

Crude Oil Production

The oil flow begins with the production of crude oil from the nearly 600,000 producing wells in the United States. Average production per well is about 13 barrels a day. 3/ Although these wells are owned by over 9,000 different firms, about 20 of the largest oil companies account for about half the crude oil production. According to data developed by the Chase Manhattan Bank from annual reports of oil companies, 32 of the leading companies in the industry increased their share of domestic crude production from 62 percent to 65 percent of the Nation's total between 1959 and 1963 (1). Most of this gain was achieved by five of the largest firms.

Total U.S. crude oil supplies amounted to about 3.3 billion barrels in 1965, according to the Bureau of Mines (13). Of this total, domestically produced crude oil accounted for 2.8 billion barrels and imported crude oil some 452 million barrels. Natural gas liquids produced in 1965 amounted to another 441 million barrels.

Had there been no controls, imports of crude oil would probably have been higher. However, under the import control program which became effective in March 1959, imports of crude oil, unfinished oils, and refined products other than residual fuel oil are limited to 12.2 percent of the estimated total domestic production of crude oil and natural gas liquids, exclusive of that in the seven States west of the Rocky Mountains (Washington, Oregon, California, Nevada, Arizona, Alaska, and Hawaii). In those States, the import quota is based on the difference between the estimated available domestic supply and estimated total demand. Overland receipts (imports from Canada and Mexico) are exempted from provisions of the program.

Crude oil is pushed to the wellhead by forces in the reservoir, usually some combination of gas, water, and gravity. In the flush stage of a new field, there is often enough pressure in the reservoir to force oil to the surface--which may be a mile or two above the oil pool. Later, as pressure declines, the flow ceases and the well must be pumped, and may eventually be subjected to secondary recovery methods (to restore the reservoir energy). When the flow slows to the point where it is no longer economically productive, the operation is abandoned. Crude oil recovery methods have improved in recent years, but much oil is never recovered. In the early days of the petroleum industry, as much as 75 percent of the oil in a field was left in the ground.

Secondary oilfield recovery processes have improved recovery rates and some abandoned oil and gas fields have been brought back into production. These methods accounted for about 32 percent of domestic oil production in 1965, compared with about 16.5 percent in 1950 (11). Current estimates indicate that by 1975 or 1980 perhaps as much as 40 percent of the domestic crude oil will be produced by secondary processes.

3/ Petroleum barrel is 42 gallons.

Petroleum Refining

The refinery segment of the oil industry is characterized by round-the-clock, high-volume output. There is a well-defined trend toward larger and fewer plants. The number of smaller companies is decreasing, as is their total share of production. The total number of refineries in 1950 was 357, operated by 218 companies. By 1963, the numbers had declined to 304 refineries and 151 companies.

On January 1, 1966, there were 286 U.S. petroleum refineries with a total throughput capacity (quantity of crude oil that can be refined in a given time) of about 10.5 million barrels per day (table 2).

Refining units separate crude oil into various fractions. Refiners try to obtain the greatest share of the most valuable fraction, which, since the early 1900's, has been gasoline. Various grades of gasoline accounted for 48 percent of output of domestic refineries in 1965.

In earlier days when heavier fractions such as kerosene were in greatest relative demand, a low-cost, hand-tended refinery was sufficient. Today, capital outlay for a refinery plant is immense. A 10,000-barrel-a-day refinery--small by current industry standards--requires a $10 million investment. Usually, operating economies dictate that the refinery be considerably larger. In fact, average capacity of the 139 refineries owned by the 23 largest companies is well over 60,000 barrels a day. These are complex, highly integrated plants with an average investment of more than $50 million, explaining why the refining part of the petroleum industry is more concentrated than the producing segment.

Refineries fared less well in the earlier part of the period from 1950 to 1963 than in the latter part. Between 1950 and 1954, they were caught in a cost-price squeeze. Operating costs rose from 90 cents to more than $1.10 a barrel. However, by 1958, refiners began to reap benefits of production economies associated with larger fractionation units and greater throughput per worker. Throughput per worker increased from 37 barrels daily in 1948 to 59 in 1956, and 83 in 1962. Average refining costs continued to rise--up to $1.25 per barrel in 1957--but then tended to level off (11).

Table 2.--Number of refineries and daily capacities, United States, selected years, 1950-66

Year	Refineries	Total throughput capacity per day	Average capacity per refinery per day
	Number	Thousand barrels	Thousand barrels
1950	357	6,842	19.16
1960	310	9,972	32.17
1963	304	10,300	33.88
1965	300	10,774	35.91
1966	286	10,493	36.69

Source: (11) and Bureau of Mines, U.S. Department of the Interior.

Transport of Petroleum

Crude oil is shipped to major refineries and refined products to market areas mainly by pipeline. However, sizable quantities travel up the Mississippi-Ohio river system by barge, and from the Gulf Coast to the East Coast by seagoing tanker. Almost all short-haul distribution of refined products within market areas is by tank truck. Railroads do some medium-haul transporting of special new products. Water transport, whether by tanker or barge, is the cheapest method of moving petroleum and is becoming even more so with increasing use of large ships (some exceeding 500,000 barrels capacity) on long-haul routes. These various forms of transportation may be in partial competition with each other, but typical petroleum movement may use them all, and they usually complement each other.

Of the crude oil received by domestic refineries in 1965, 75 percent was shipped by pipeline, 24 percent by tanker and barge, and 1 percent by railroad and truck. Of bulk petroleum products moved out of refineries, 45 percent went by pipeline, 25 percent by tanker, and the remaining 30 percent by tank truck, barge, and railroad.

The U.S. oil pipeline system, totaling about 211,000 miles, is by far the most extensive in the world. Of the total, about 77,000 miles are part of the crude-oil gathering systems in oilfields, 72,380 miles are crude oil trunklines, and 61,400 miles are petroleum-product pipelines extending from refineries to distribution terminals serving major cities. In addition to the petroleum pipeline system, there are 265,000 miles of natural-gas gathering and transmission pipelines and about 459,000 miles of distribution mains (11).

The cost of crude oil transportation is a comparatively small percentage of the value of domestic crude oil in U.S. refineries. For example, the 1958 average cost of domestic crude oil in U.S. refineries was $3.25 a barrel. Transportation represented only 23 cents a barrel, or about 7 percent.

One result of the development of the network of pipelines feeding various refineries is a reduction in inventories or feed stocks required for refinery operations, which are consequently more efficient. Actual working stocks of crude at the refinery site today average only 8 days' supply, backed up by 19 days' fill stock in the delivery pipeline system, or a 27-day inventory. In 1930, inventories were equivalent to a 5-month supply of refinery stocks plus that held in pipelines and tankers. By 1940, the stock level had dropped to about 64 days and by 1950 to 42 days.

Supply and Distribution System

To recapitulate, crude oil production in 1963 was estimated at 2.8 billion barrels with a wellhead value of about $8 billion (fig. 1). Net imports contributed an additional 413 million barrels. Refinery inputs totaled 3,171 million barrels with an estimated value of $13.2 billion. Output value of refineries in 1964 was estimated at $16.3 billion. The $3 billion difference is value added by the refineries (12).

From refineries, petroleum products are transported to consumers. It is estimated that the commercial transportation industry took over half (52 percent) of domestic refinery output during 1963 (11). Many transportation firms are large enough users to maintain their own bulk terminals supplied by pipeline, river barges, tankers, or rail. About 19 percent of refinery output went to industrial users as raw

The Petroleum Industry: Supply and distribution system, 1963 (millions of 42-gallon barrels)

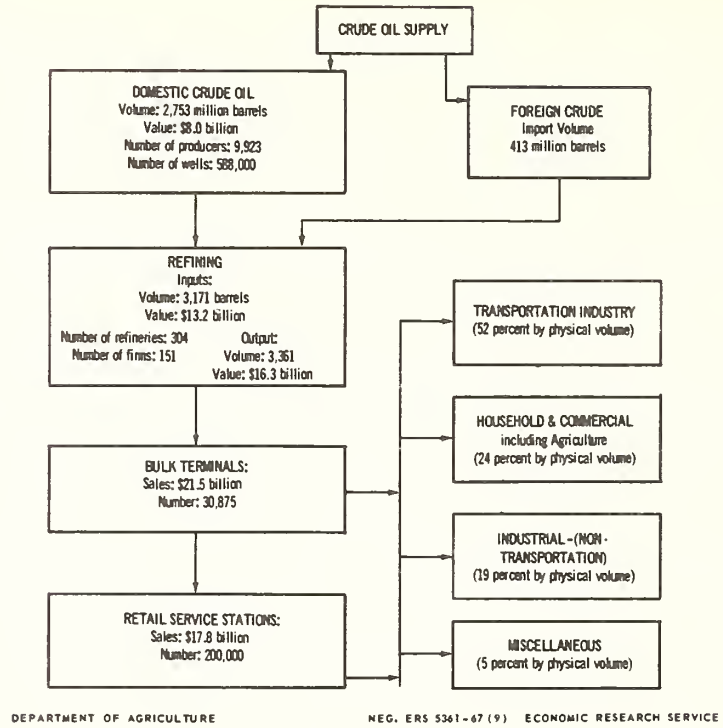

Figure 1

materials for further processing in 1963. Miscellaneous uses accounted for 5 percent. The remaining 24 percent was consumed by households and commercial users--including agriculture, which accounted for 5 percent (11).

Final links in the distribution chain are bulk plants and neighborhood service stations. Bulk plants receive gasoline and other materials in bulk or in containers, and in large quantities. From a relatively large product inventory at the bulk plant site, supplies are sent to service stations in local markets. In rural areas, one or two local communities or a county may be designated as a marketing area by a particular oil company. In 1963, 30,875 bulk plants were reported to have sold products worth $21.5 billion (11).

Service stations are the major outlet for highway, noncommercial users. During 1963, there were some 211,000 of these units with combined gross sales of nearly $18 billion. Bulk plants not only supply service stations but they may also sell heating oil directly to consumers in their market areas. In addition, they almost always deal directly with light commercial users and farmers.

The Distribution System Serving Agriculture

The long-time rise of mechanization in agriculture has been accompanied by increasing consumption of petroleum products on farms (tables 3 and 4). Farmers require large quantities of fuel for tractors, trucks, automobiles, conveyors, and such power units as combines and other self-propelled machines. They apply pesticides with oil bases. They also use many lubricants for their equipment and large quantities of heating oil and liquefied petroleum gas in the home and in farm buildings.

Table 3.--Consumption of motor fuel by farm tractors, United States, specified years 1/

Year	Gasoline	Diesel	Kerosene	LP-gas	All other	Total fuel
	Million gallons	Million gallons	Million gallons	Million gallons	Million gallons	Million gallons
1947	2,245	121	79	2/	375	2,820
1953	2,738	216	2/	85	232	3,271
1959	2,669	337	2/	300	64	3,370
1965 3/	2,535	600	2/	350	30	3,515
	Percentage of total fuel consumption					
	Percent	Percent	Percent	Percent	Percent	Percent
1947	79.6	4.3	2.8	2/	13.3	100.0
1953	83.7	6.6	2/	2.6	7.1	100.0
1959	79.2	10.0	2/	8.9	1.9	100.0
1965 3/	72.1	17.1	2/	10.0	.8	100.0

1/ Excludes Alaska and Hawaii. 2/ Included with other fuels. 3/ Preliminary estimates by the writer.

Source: (8).

Table 4.--Farm consumption of liquid petroleum fuel, by use, United States, specified years 1/2/

Year	Motor fuel consumed by					Other fuels 3/	Heating fuels for household use	All uses	
	Tractors	Automobiles	Motortrucks	Other power units	All power machines			Total	Average per farm 4/
	Million gallons	Million gallons	Million gallons	Million gallons	Million gallons	Million gallons	Million gallons	Million gallons	Gallons
1947	2,820	1,695	845	278	5,638	5/	1,459	7,097	1,209
1953	3,271	2,073	1,069	362	6,775	456	1,577	8,808	1,767
1959	3,370	1,639	1,064	379	6,452	421	1,737	8,610	2,101
1965 6/	3,515	1,650	1,160	500	6,825	450	1,800	9,075	7/2,750
	Percentage of total use								
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
1947	39.7	23.9	11.9	3.9	79.4	5/	20.6	100.0	---
1953	37.1	23.5	12.1	4.1	76.9	5.2	17.9	100.0	---
1959	39.1	19.0	12.4	4.4	74.9	4.9	20.2	100.0	---
1965 6/	38.7	19.3	11.7	5.5	75.2	5.0	19.8	100.0	---

1/ Excludes Alaska and Hawaii.
2/ Does not include motor oil or other lubricants, natural, or utility gas.
3/ Used for drying crops; brooding, killing weeds; heating water, buildings, and orchards; and miscellaneous other uses.
4/ Based on "Number of Farms, 1910-1959, Land in Farms, 1950-1959, by States," U.S. Dept. Agr., Statis. Bul. 316, June 1962.
5/ Included in household use.
6/ Preliminary estimates by the writers.
7/ Based on estimated 3.3 million farms.

Source: (8).

Bulk plant operators usually cultivate farm accounts aggressively. In predominantly agricultural areas, farm consumption of petroleum products may exceed that of retail service stations. In many locations, the same tank truck may make deliveries to both farms and service stations supplied by the bulk plant. Farmers generally pay bulk tank prices for most of their liquid petroleum fuel. These prices are usually a few cents below local service station retail prices. In addition, farmers may receive a tax rebate on fuels used for farm production.

Frequently, farmers obtain deliveries from a specific dealer on a regularly scheduled basis. A farmer may, or may not, own the fuel storage tanks and pumps on his farm. If he owns storage tanks, he is relatively free to switch dealers when he chooses, but when the title to such equipment is held by the distributing firm, the farmer tends to be a steady patron.

Farmers also consume considerable quantities of petroleum products for uses not directly associated with farm business (table 5). Included are fuel for heating homes, the nonbusiness share of gasoline, oil, and lubricants used in automobiles, and so on. These costs are about a fourth of the amount spent for petroleum products used by farmers. Since off-farm gasoline use is subject to State highway users' taxes and farm use is not, expenditures for the two classes of consumption do not reflect comparable volumes of consumption. In total, combined expenditures for petroleum products by farmers exceeded $1.8 billion in 1964.

Table 5.--Estimated petroleum expenditures for farm production and farm household consumption, by type of use, United States, 1964 1/

Petroleum use	Expenditure by type of use	Percentage of expenditures
	Million dollars	Percent
Motor fuels used in--2/		
Tractors	716.4	49.1
Motortrucks	226.1	15.5
Automobiles	347.2	23.8
Other motors	80.2	5.5
Other consumption	89.0	6.1
Total production fuels	1,458.9	100.0
Farm household fuel consumption	364.8	---
Total petroleum expenditures by farmers	1,823.7	---

1/ Excludes Alaska and Hawaii.
2/ Included with the motor fuel consumption data are the various motor oils and lubricants for maintenance.

Source: (8).

Petroleum Products Handled by Cooperatives

Net sales of petroleum products handled by 2,836 farmer-owned cooperatives amounted to about a fourth of total farmer expenditures for petroleum products (used in farming and in farm homes) in the year ended June 30, 1964 (9). The three leading States in sales of petroleum products handled by cooperatives--Iowa, Minnesota, and Illinois--accounted for about 27 percent of the total cooperative volume in 1964 (table 6).

Farmers have a substantial stake in the petroleum industry through their cooperative ownership of retail bulk plants, tank trucks, refineries, crude oil deposits, pipelines, and terminals (6). Current estimates indicate total cooperative investment in these activities (using cost values) is about $250 million, mainly concentrated in refining and wholesale and retail distribution. Output of liquid fuels by the eight cooperative refineries is about equal to the quantity distributed by all retail cooperatives. Like other farm-oriented supply firms, cooperatives have been faced with the general decline in number of farms and farmers. But the declining number of patrons has been nearly offset by the increasing average farm size, and has resulted in increased purchases by individual farmers along with greater availability of services, including extension of credit.

Because of need to maintain sufficient volume for net savings or net income in the event of a leveling-off of farm market demand, most cooperatives now strive to supply the nonfarm, but generally rural, petroleum market.

Table 6.--Estimated net sales of petroleum products by farmer cooperatives in the 10 highest ranking States in the year ended June 30, 1964, and their rank in sales in 1964 and 1954

State	Net sales		Rank	
			1964	1954
	Thousand dollars	Percent		
Iowa	61,270	9.4	1	3
Minnesota	60,510	9.3	2	2
Illinois	53,377	8.2	3	1
Kansas	47,585	7.3	4	7
Wisconsin	46,425	7.1	5	5
Nebraska	43,337	6.7	6	6
Indiana	40,591	6.2	7	4
South Dakota	32,205	5.0	8	9
North Dakota	31,929	4.9	9	8
New York	27,101	4.2	10	12
Others	205,812	31.7	---	---
Total	650,143	100.0	---	---

Sources: (4,9).

Looking Ahead

Marked changes in the petroleum industry in the last two decades have been strongly influenced by expanding technology. The increasing use of natural gas has been a major growth factor in the energy economy, and the accompanying production of liquids is also important in the structure of the industry. Secondary recovery operations are now a partial alternative to the traditional pattern of finding and developing new sources of petroleum.

Oil discoveries in recent years have not maintained earlier ratios of reserves to consumption (11). However, with greater investment of men and equipment in oil discovery and development, improvements in secondary recovery techniques, further refinery efficiencies, and greater reliance on imports, additional oil supplies probably will become available. Much of the groundwork for extraction of oil from oil shale and bituminous coal seems to have been demonstrated by pilot plants. Continuing research and development will eventually open more of these hydrocarbon resources to economic competition. The need for petroleum fuels for steam generation may also be eased as new atomic fuels are increasingly used by large industrial users.

The farm petroleum market is expanding despite declining numbers of farms and farmers. In fact, data from the 1964 Census of Agriculture indicate that farmers' expenditures for petroleum fuels increased more rapidly from 1959 to 1964 than in the preceding 5 years. Several factors account for the recent rise in use of petroleum products in agriculture. Among these are a marked increase in the horsepower of individual power units on the farm(both tractors and self-propelled, specialized equipment) and greater use of petroleum heating oils for the farmstead, orchards, groves, and stationary processing equipment.

Even though there has been a sharp decline in the number of farms, there has not been a corresponding decline in the numbers of tractors, self-propelled equipment, and other machinery. The outlook suggests a continuing and increasing demand for petroleum products on U.S. farms, and a continuing trend toward tractors designed for diesel fuel and LP gas.

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NOTE 2--FARM MACHINERY AND EQUIPMENT

by

Paul E. Strickler 1/

The General Setting

Many technologies contribute to the high level of farm productivity. None is more important than that of the machines that multiply the effectiveness of human labor.

Several factors affect the market for farm machinery--the fluctuating level of farm income, the decrease in the total number of farms, the increase in the number of larger farms, changes in production technology (2, 8, 13). 2/ The core of the market for new machinery consists of less than a million commercial farms with annual sales of $10,000 or more. In 1965, these farms made up about 40 percent of commercial farms and 28 percent of all farms (13). Operators of these larger farms buy most of the new tractors and tractor-powered or self-propelled machinery and implements made by farm equipment manufacturers (tables 1 and 2).

Smaller farms, including many part-time farms, provide a market for some new equipment especially in small sizes. More importantly, these farms provide an outlet for used machinery. Since the number of small farms is shrinking rapidly, there is some concern about the future market for used machines.

The Industry Structure

Manufacturers of farm equipment are characterized as "full-line," "long-line," and "short-line" producers. The full-line companies are those that produce tractors plus a complete line of tractor-powered equipment, self-propelled equipment, attachments, and other agricultural machines. Only seven companies are classified as full-line firms: Allis-Chalmers Manufacturing Company, J.I. Case Company, Deere and Company, Ford Motor Company, International Harvester Company, Massey-Ferguson, Ltd., and White Motor Corporation. Each of two domestic subsidiaries of White Motor Corporation--Oliver Corporation and Minneapolis-Moline, Inc.--makes a full line of farm machinery.

The long-line machinery companies are generally smaller than full-line companies and tend to be more specialized. Some long-line companies are Gehl Brothers Manufacturing Company, New Holland Machine Company (Division of Sperry-Rand Corporation) and New Idea Farm Equipment Company (Division of Avco Corporation).

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2/ Underscored numbers in parentheses refer to Selected References, page 24.

Table 1.--Machinery for farm use: Number and value of selected items for domestic farm use, United States, 1965 1/

Item	Units shipped	Total value	Average value per unit
	Number	Thousand dollars	Dollars
Tractors:			
Wheel-type: 2/			
9-34 hp.	8,685	17,190	1,979
35-49 hp.	53,313	133,225	2,499
50-69 hp.	51,101	183,816	3,597
70-89 hp.	19,832	81,142	4,091
90 hp. and over	42,710	206,574	4,832
Tracklaying tractors	1,593	21,399	13,559
Garden tractors and motor tillers	446,378	98,691	221
Other machines and equipment:			
Corn planters and corn cotton planters, drawn and mounted	63,960	20,693	324
Loaders-manure and general utility	29,909	13,568	454
Tandem disk harrow	71,236	37,816	531
Combines:			
Pull-type (over 6 ft.)	1,992	5,652	2,837
Self-propelled without heads:			
Under 14 ft.	7,779	30,619	3,936
14-16 ft.	7,432	33,615	4,523
16 ft. and over	12,730	78,106	6,136
Grain heads for combines	27,384	15,006	548
Corn heads for combines	20,215	30,151	1,492
Cornpickers, 2-row drawn and mounted	8,061	15,663	1,943
Cottonpickers	4,289	40,041	9,336
Cotton strippers	1,997	3,616	1,811
Pick-up hay balers:			
Wire	7,516	14,583	1,940
Twine	40,055	49,450	1,235
Hay conditioners	15,968	8,427	528
Field forage harvesters	25,191	27,019	1,073

1/ Value shown is net selling value, f.o.b. plant.
2/ Except garden-type.

Sources: (10,12).

Table 2.--Machines and equipment for farm use: Value of manufacturers' domestic shipments, United States, 1955-57 and 1963-65, and percentage change

Item	Average 1955-57	Average 1963-65	Percentage change 1955-57 to 1963-65
	Million dollars	Million dollars	Percent
Complete tractors and attachments and parts 1/	521.3	776.5	49
Other machinery and equipment (including parts)	816.3	1,181.8	45
Planting, seeding, fertilizing	80.9	118.0	46
Harrows, rollers, stalk cutters, pulverizers	66.9	117.7	76
Plows and listers	56.0	80.6	44
Harvesting machinery	219.9	386.4	76
Haying machinery	139.6	121.6	-13
Farm dairy machinery and equipment	18.5	22.2	20
Sprayers and dusters	35.9	44.4	24
Elevators and blowers	34.0	28.9	-15
Cultivators and weeders	46.4	61.3	32
Machines to prepare crops for market or use	31.3	50.6	62
Farm poultry equipment	29.5	38.6	31
Barn and barnyard equipment	32.6	62.2	91
Farm wagons and trucks	25.3	49.3	95

1/ Excludes attachments and parts for crawler tractors.

Sources: (10,12).

Short-line companies produce specialized mechanical and automatic equipment such as that used in the feeding and care of livestock and poultry. Their volume of business is usually less than that of either full-line or long-line firms.

According to the 1963 Census of Manufactures, the "Farm Machinery and Equipment Industry" consisted of 1,562 establishments, an increase of 6 percent since 1958.3/ The number of firms with 20 or more employees was 555, a 9-percent increase in the same time.

Tractor manufacturers (mainly the full-line companies) were responsible for about two-thirds of the sales of all farm machinery in 1964. Sales of tractors and self-propelled machines together represented more than half the value of domestic shipments of farm machinery and equipment (10, 12). About 10 percent of the industry's volume came from about 15 long-line concerns that produced specialized equipment.

3/ The 1963 Census of Manufactures is the latest available.

The data in table 3 show the degree to which the full-line companies were diversified in 1965. Deere & Co., for example, concentrated its activities on farm machinery production, with only 16 percent of its business outside the farm machinery industry. On the other hand, farm machinery accounted for no more than 5 percent of the business of the Ford Motor Company.

Activities of Full-Line Firms 4/

Allis-Chalmers Manufacturing Company is one of the leading producers of agricultural, construction, industrial, and electrical machinery and equipment. Manufacturing facilities are in both the United States and Canada. Production and sales are handled by three operating groups--tractor, industrial equipment, and utilities. In 1964, sales of farm and industrial tractors and associated equipment were 61 percent of consolidated sales of $629 million. Sales of farm machinery accounted for slightly less than half of the sales of the tractor division. Exports from plants in the United States and Canada were 12 percent of total sales.

J.I. Case Company, in addition to farm machinery, produces industrial equipment for general construction, earth moving, and road building. Case distributes its products through branch sales offices serving about 2,400 retail outlets in the United States and Canada. Kern County Land Company acquired control of this firm in 1964.

Table 3.--Full-line companies: Total sales, rate of net return, and estimated diversification, United States, 1965

Company	Total sales	Rate of net return on sales	Farm machinery sales as a percentage of total sales 1/
	Million dollars	Percent	Percent
Allis-Chalmers Mfg. Co.	714.4	3.1	30
J.I. Case Co.	273.6	3.9	70
Deere & Co.	886.6	6.2	84
Ford Motor Co.	11,536.8	6.1	2/5
International Harvester Co.	2,336.7	4.3	34
Massey-Ferguson, Ltd.	808.5	5.0	75
White Motor Co.	638.2	3.5	25

1/ Calculated or estimated by the writer from data in annual reports and other published material.

2/ Domestic market.

Sources: (7) and annual reports of corporations.

4/ As published in (7) and in annual reports of the corporations.

Deere & Company is one of the principal domestic manufacturers of farm machinery, with a small but rapidly growing line of industrial equipment. Garden equipment was added in 1963. Overseas sales have expanded along with domestic sales. In 1964, 84 percent of Deere's sales were in the United States and Canada, 8 percent in Europe, and 8 percent elsewhere.

Ford is an integrated and highly diversified firm in which farm machinery sales are only a small fraction of the firm's gross dollar volume. In addition to automobiles and trucks, various industrial and chemical products are made. To streamline marketing of farm equipment, Ford in 1964 began selling directly to its 2,000 dealers of farm and light industrial equipment, eliminating the need for distributors in the marketing chain. In 1965, Ford became the seventh full-line manufacturer to handle garden tractors and equipment.

International Harvester Company, the principal domestic maker of heavy motortrucks, is also one of the largest producers of farm, industrial, and garden tractors and equipment. Other products include excavating and earth-moving equipment. With its own coal mines, steel mills, coke ovens, and sisal plantations in addition to its manufacturing facilities, the firm has achieved a high degree of vertical integration. The firm's farm equipment is sold through 8,400 independent dealer outlets, throughout the United States and Canada.

Massey-Ferguson, Ltd., a Canadian-based firm, through its subsidiaries, is one of the largest producers of farm machinery in the world and largest in the British Commonwealth. In addition to its broad line of farm machinery, Massey-Ferguson also makes diesel engines for automotive, marine, and industrial use; office furniture; and light industrial equipment.

White Motor Corporation, a manufacturer of industrial and commercial motor vehicles, diversified into farm machinery in 1960 with the acquisition of Oliver Corporation. In 1962, it acquired Cockshutt Farm Equipment, Ltd., a Canadian firm, and in 1963, Minneapolis-Moline, Inc. These three firms were all full-line manufacturers of farm machinery. By 1965, farm machinery sales amounted to about a fourth of the firm's gross volume of $638 million. Truck sales represented nearly half of the total; diesel engines, construction, and industrial equipment and parts for all products accounted for the remaining fourth.

Product Changes

Farm equipment makers and research agencies look continually for ways to substitute mechanical power for muscle power, to bring together operations previously performed separately and to put farm products in more usable form in the field as they are gathered. Recently, they have sought ways to process feed for automatic handling and to modify man's dependence on nature in growing, harvesting, and curing feed crops.

Although major breakthroughs into all-new products happen only occasionally, improvements and refinements in long-established products are continuous. Major recent trends have been in the direction of larger tractors and equipment, more fully automatic operations, and engines adapted to more economical fuels.

The shift to more powerful tractors is shown by the fact that 64 percent of the wheel-type (other than garden) units shipped in 1966 were 50 horsepower or more, and 26 percent were 90 or more. Ten years earlier only 19 percent were 50 horsepower or more. Preference for diesel wheel tractors continued through 1966 when 58 percent of the shipments were of this type. Of the diesel tractors, nearly half were 90 horsepower and more in 1966 (10, 12). In 1966, most makers offered tractors with size ratings ranging from 1 to 8 plow bottoms (6).

Transmissions in farm tractors are almost as important as engines. Like engines, they have been improved and made more flexible, increasing efficiency and versatility. For example, the average number of tractor forward speeds increased from 4.8 to 8.4 between 1947 and 1963. Transmissions now allow shifting while the tractor is in motion and transmitting full power. Two of the most common types offer shifting between ranges or full power shifting of all forward and reverse speeds.

More numerous travel speeds add to tractor flexibility by permitting better matching of available engine power and speeds with both varying and specific operating requirements. For example, tillage operations present varied conditions which often require power in excess of an engine's reserve torque. Increased power take-off usage presents situations, such as running a forage harvester, where a definite engine speed is needed to maintain power take-off speed (5).

Marketing and Distribution

Marketing farm equipment presents problems to manufacturers and distributors in determining farmers' buying motives, forecasting trends in farm prices and income, deciding on numbers of dealers, analyzing supplier-dealer relationships, and improving sales financing.

A recent study of commercial farmers covering many aspects of farmers' machinery buying habits (1) mentioned the farmers' reasons for buying their biggest tractor as: More power needed, 78 percent; to perform job faster, 57 percent; farming more land, 44 percent; and old tractor worn out, 42 percent. Most farmers checked more than one reason.

The reasons most frequently given first for place of purchase of major farm machinery units were: Brand of equipment sold by dealer, 34 percent; dealer's parts and service policies, 27 percent; and price, cost, or best deal on machinery, 25 percent. These responses indicated that price is important to farmers; but other factors, such as brand loyalty and dealer performance, also influence their decisions. Some dealers have done more than others to meet farmers' needs by providing quick service, and giving more attention to special items (4).

Price increases for farm machinery trailed those of all machinery and motive products from 1953 through 1962 largely because of instability in the farm market. Changes in this market after 1962 enabled farm machinery manufacturers to bring their prices in line with, or slightly above, those for all equipment and motive products. The Bureau of Labor Statistics wholesale price index for farm machinery and equipment had risen 33.5 points by 1957 from the 1947-49 base, compared with a rise of 46.2 points for all machinery and motive products. By 1965, the farm group was 60.7 points above the base, compared with 55.2 points for all. While machinery prices have become higher, so have engineering and research expenditures. For

example, in 1965, International Harvester reported spending $63.8 million for such purposes compared with $52.0 million in 1960. Deere has more than tripled its annual outlays for product research and development in the last 10 years.

Recent trends show fewer dealers and a larger volume of business per dealer. Dealers handling mainly farm machinery totaled 16,362 at the end of 1963, compared with 19,008 only 5 years earlier. Dealers' sales averaged $222,000 in 1964, up from $167,000 in 1958 (11). According to counts made by the Farm & Industrial Equipment Institute, the number of dealers declined to 16,297 in 1965 and to 15,165 in 1967.

Most of the larger farm machinery companies have instituted dealer development programs. Through these programs, top level assistance is available to dealers from the company and its branches.

Distribution Channels

Distribution channels between farm machinery manufacturers and farmers must be seen from the vantage points of the several segments of the industry. The structure of the distribution is perhaps more definite for the full-line and long-line companies, as outlined in the flow chart in figure 1. These companies have national organizations and maintain continuing relationships with their dealers. The short-line producers must seek a more varied set of channels as suggested in figure 2. These companies do not have some of the expenses that must be met in maintaining a full-line of equipment with the accompanying overhead, but they must make more market contacts. Exports and imports are handled through some of the channels.

With limited financial resources, dealers frequently need help in financing inventories and customer sales. Since about 1948, this need has been met increasingly by machinery manufacturers. Some of them also provide leasing arrangements. Most of the large manufacturers now have credit subsidiaries to aid branches and dealers in financing. Banks also are active in this field.

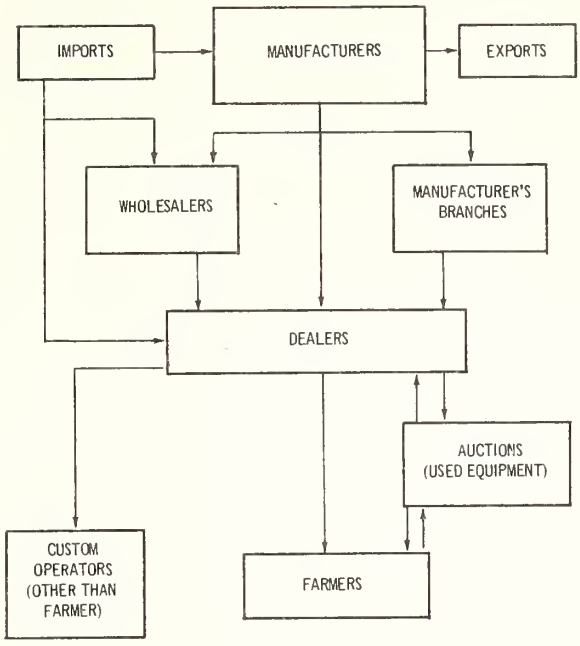
Farmer cooperatives handle a very small percentage of the equipment farmers buy. In 1964-65, about 1,600 associations had net sales of $72 million of farm machinery and various types of farm equipment--about 2 percent of farmers' total expenditures for such items (9).

Foreign Trade

From 1960 through 1965, exports of farm machinery, wheel tractors, tracklaying tractors, and attachments and parts amounted to about 25 percent of the total shipments by domestic producers of these items. In 1965, the value of these exports was $865 million (table 4). Exports of machinery mainly for use on farms, which excludes most of the tracklaying tractors, amounted to about $430 million in 1965 (15). Data on exports do not include items produced by foreign subsidiaries of domestic firms. For example, International Harvester produces and sells farm equipment in Canada, South America, Europe, Australia, and Africa.

Of the various foreign markets in 1965, Canada accounted for the largest share of U.S. exports and was followed at a distance by Western Europe, with Latin America third (table 4). Exports tend to fluctuate widely by region. Shipments of farm machinery and all tractors to Canada were a record $330 million in 1965, up

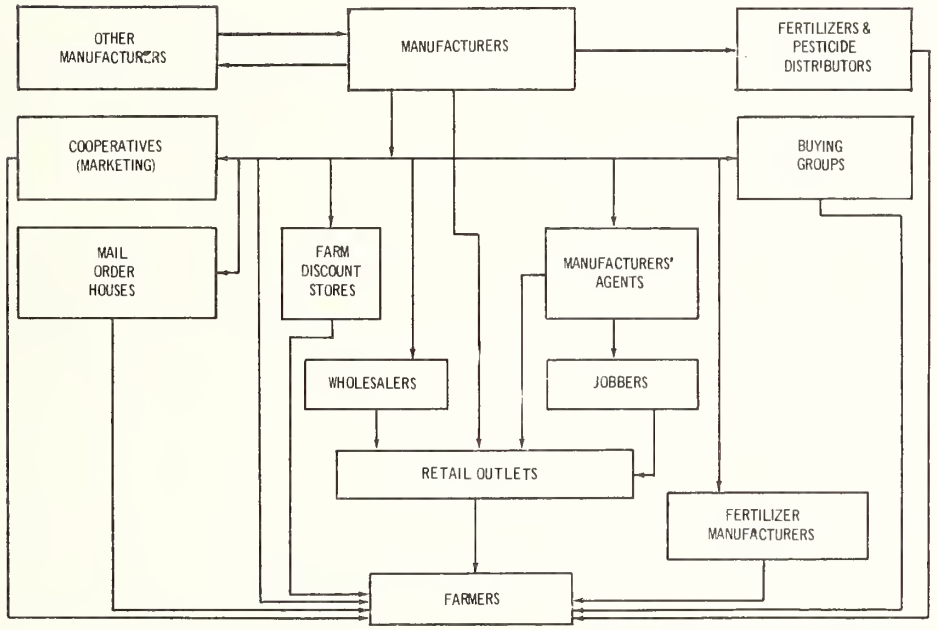
Distribution Channels of Farm Machinery: Full-Line and Long-Line Companies



U. S. DEPARTMENT OF AGRICULTURE NEG. ERS 5355-67 (9) ECONOMIC RESEARCH SERVICE

Figure 1

Distribution Channels of Farm Machinery: Short-Line Companies



U. S. DEPARTMENT OF AGRICULTURE NEG. ERS 5356-67 (9) ECONOMIC RESEARCH SERVICE

Figure 2

Table 4.--U.S. exports of agricultural machinery, wheel and tracklaying tractors, accessories, and parts, 1960 and 1965

Country or region of destination	1960	1965	1965 as a percentage of 1960	Distribution by destination, 1965
	Million dollars	Million dollars	Percent	Percent
Canada	198	330	166.7	38.2
Latin America	123	143	116.3	16.5
Western Europe:				
Common Market	36	79	219.4	9.1
United Kingdom	9	33	366.7	3.8
Total 1/	74	159	214.9	18.4
Near East	14	31	221.4	3.6
Far East	37	59	159.5	6.8
Australia, Oceania	33	62	187.9	7.2
Africa	44	66	150.0	7.6
Total 2/	532	865	162.6	100.0

1/ Includes exports to destinations not shown separately.
2/ Detail does not add to totals because exports to some destinations are not shown.

Source: (14).

$91 million from the previous high in 1959. Exports of these items to Latin America peaked at $156 million in 1957 and declined to $143 million in 1965. Volume in this part of the world continues to reflect the loss of the Cuban market which took $10 million of machinery in 1959.

U.S. imports of agricultural machines, wheel tractors, and parts ranged from $114 million in 1961 to $249 million in 1965 (16). Canada, the principal trade outlet for exports, is also the principal source of imports, supplying $170 million or 68 percent of the total in 1965.

Looking Ahead

The farm machinery industry has had several recent years of good business. A number of factors have resulted in sharp annual increases in domestic shipments of tractors and equipment since 1960 (table 5). These factors include higher levels of farm income, rapidly changing farm technology requiring new equipment, and replacement of existing machines with larger improved ones as farm units become larger and as older machines become obsolete.

Manufacturers have probably been better able to anticipate and meet farmers' needs. Production and marketing facilities are adjusting to new conditions. The trend toward larger farms will probably build stability into the market. Two newly developing areas, the mechanization and automation of materials handling and the mechanical harvesting of fruits and vegetables, offer special challenges to farm-equipment makers.

Table 5.--Index numbers of value of domestic shipments of farm machinery and equipment, United States, 1955-66

(1957-59=100)

Year	Tractors 1/	Other machinery and equipment 2/	Total
1955	97.2	87.5	91.2
1956	78.4	80.7	79.8
1957	87.8	85.7	86.5
1958	99.5	105.4	103.2
1959	112.7	108.9	110.3
1960	79.0	95.3	89.1
1961	94.1	96.2	95.4
1962	106.8	99.9	102.5
1963	116.4	112.4	113.9
1964	121.9	121.1	121.4
1965	152.0	128.7	137.6
1966 3/	215.9	152.3	176.5

1/ Includes wheel and tracklaying tractors for farm use, garden tractors and motortillers for all uses, and attachments and parts for wheel tractors, garden tractors, and motortillers.

2/ Includes self-propelled machines.

3/ Preliminary.

Sources: U.S. Bureau of the Census, Current Industrial Reports (10,12).

Materials handling from fields to storage and at the farmstead requires a mechanized, uninterrupted flow to be highly efficient. Systems to achieve this through automation are in various stages of experimentation and production. For example, some dealers can now provide a fairly complete, automated livestock-handling package. They can supply cattle farmers with custom units consisting of buildings, feed mixers, automatic delivery augers for feed bunkers, silos with mechanical unloaders, automatic manure removers, air-conditioners, and humidity control devices.

A gradual approach to the "systems" concept is the manufacture of a package of equipment that can be sold in parts to the farmer as his needs and financial situation permit. Marketing and installing these segments takes experience, management ability, and engineering sense.

Mechanized field-to-storage harvesting routines are in sight in the Corn Belt. A train of machines consisting of cornpicker-shellers and hauling, drying, and storage equipment synchronized to the picking-shelling rate is already operational. A further step proposed for this system is refrigerated storage for corn to be dried, preventing spoilage and thus leveling the heavy demand for corn-drying capacity at harvesttime.

Prospective domestic and world needs for food and fiber would seem to point to sustained high demand for farm machinery and equipment. Assessing the future demand for agricultural machinery and equipment is not a precise undertaking.

Rapidly changing technology makes obsolescence an increasingly important factor. Larger farms will require larger units of equipment but fewer units will be needed. Some specialized pieces of equipment may be used relatively little on an annual basis but are economical in the long run because of timeliness and concentrated use in critical periods. Machines may become technically obsolete before they wear out.

In addition to direct production equipment, more and more auxiliary equipment such as computers and electronic controls will be available to aid farmers in the years ahead, whether owned, leased, or included with a service.

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NOTE 3--FERTILIZERS

by
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Background and Setting

Few industries have undergone as much change in volume and in quality of product in the last 20 years as the chemical fertilizer industry in the United States. Fertilizers consist chiefly of a wide assortment of chemical compounds, or mixtures of compounds, containing one or more primary plant nutrients--nitrogen, phosphorus, and potassium. Lesser tonnages of materials containing secondary nutrients and micronutrients also are marketed. Most of the industry's outputs are the products of highly complex chemical processes and are marketed as solids, liquids, or gases; in bulk or in bags; by truck, rail, or water; to farmers and nonfarmers.

Modern American farming practices rapidly deplete soils of plant nutrients, most commonly nitrogen, phosphorus, and potassium. Producers and distributors of chemical compounds or mixtures containing these elements constitute the broadly defined chemical fertilizer industry.

Fertilizer sales for farm use from January 1 through December 31, 1966, were nearly $1.8 billion (8). 2/ From 1956 to 1966, dollar sales to farmers increased 64 percent. During the same years, gross fertilizer tonnage consumed increased 56 percent. But more importantly, primary plant nutrient use rose 106 percent.

During the year ending June 30, 1966, over 3,200 grades of mixed fertilizer were reported sold in the 48 contiguous States (18). Of these, only 155 grades were consumed in quantities of more than 10,000 tons. Mixtures amounted to 19.4 million tons--57 percent of the total tonnage consumed. Primary, secondary, and micronutrient materials applied directly to the soil totaled 14.8 million tons--43 percent. An estimated 90 percent of the total tonnage was used in commercial agriculture; the balance was marketed for nonfarm use. Primary nutrients--nitrogen (N), available phosphorus (P_2O_5), and potassium (K_2O)--contained in mixtures and materials totaled 12.3 million tons. In mixtures alone, the tonnage of such nutrients was 7.1 million.

Changing Patterns of Use

Significant changes in patterns of fertilizer use occurred in the decade 1955 to 1965 (18). In these 10 years, the major region of consumption shifted from the Southeast to the Midwest. From July 1, 1954, to June 30, 1955, 6.1 million tons of fertilizer containing 1.4 million tons of plant nutrients were used in the South Atlantic

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2/ Underscored numbers in parentheses refer to Selected References, page 39.

States. The region ranked first among the standard census regions in both categories. In the like period of 1964-65, 6.7 million tons of fertilizer containing 1.8 million tons of plant nutrients were consumed. Nationally, the region still ranked first in tons of fertilizer used but it dropped to third place in plant nutrient consumption. The East North Central States with plant nutrient consumption of 2.7 million tons and the West North Central States with consumption of 2.3 million tons had moved far ahead of the South Atlantic States.

More than a million tons of fertilizer were used in each of 11 States in the fiscal year ending June 30, 1966. California with 3.1 million tons (including more than 1 million tons of gypsum) was the greatest user; Illinois was second with 3.0 million tons (including 244,000 tons of phosphate rock). Converted to primary plant nutrient consumption, Illinois ranked first with 1,304,000 tons, Indiana second with 906,000 tons, and Iowa third with 856,000 tons.

The Structure of the Fertilizer Industry

To understand the structure of the fertilizer industry, it is necessary to know something of the nature of fertilizer production. Each of the three primary plant nutrients--nitrogen, phosphorus, and potassium--has specific production characteristics.

Nitrogen

The principal source of nitrogen is air, and is, therefore, practically unlimited. Nitrogen combined with hydrogen under controlled conditions produces synthetic ammonia. Natural gas is the major feedstock for producing hydrogen. Other sources of hydrogen include refinery gas, naphtha, fuel oil, coke-oven gas, water gas, and electrolytic hydrogen. At least 88 percent of American ammonia production comes from natural gas. Byproduct coke-oven ammonia (ammonium sulfate, ammonia liquor, and diammonium phosphate), natural sodium nitrate, and natural organic materials are additional sources of nitrogen for fertilizer.

Direct synthesis of ammonia was a German development. Commercial production in the United States was begun in 1921 by Atmospheric Nitrogen Corporation (now Nitrogen Division, Allied Chemical Corporation) at Syracuse, N.Y. By 1940, there were seven firms producing synthetic ammonia in the United States (table 1). Since then expansion has been rapid.

Phosphorus

Phosphorus is found in all rocks, but concentration is usually too low for economic recovery of the material. However, domestic deposits that yield a relatively high proportion of phosphorus are being worked in Florida, North Carolina, Tennessee, Idaho, Montana, Utah, and Wyoming. Converted to P_2O_5 equivalent, about 80 percent of mine production of phosphate rock ore is in Florida. About 12 firms mine in the Florida rock fields.

After mining, washing, beneficiation, and drying, the rock is ground and then routed through a chemical process. End products of this process include ammonium phosphate, triple superphosphate, normal superphosphate, nitric phosphate, dicalcium phosphate, phosphoric acid, and phosphate rock.

Table 1.--Synthetic ammonia: Designed annual capacity 1/ of anhydrous ammonia by producer, United States, 1940 and 1966

Firm	1940 capacity	1966 capacity
	Thousand tons	Thousand tons
Allied Chemical Corp.	243	905
E.I. du Pont de Nemours & Co.	169	430
Shell Chemical Co.	30	312
Hercules, Inc.	12	233
Midland Ammonia Co. 2/	10	211
Mathieson Alkali Co. 3/	6	490
Pennsylvania Salt Mfg. Co. 4/	5	41
American Cyanamid Co.	---	78
American Oil Co.	---	210
Ammonia, Inc.	---	105
Apache Powder Co.	---	15
Apple River Chemical Co.	---	245
Armour Agricultural Chem. Co.	---	242
Atlantic Refining Co.	---	60
Best Fertilizer Co.	---	179
Calumet Nitrogen Products Co.	---	127
Central Nitrogen, Inc.	---	123
Chevron Chemical Co.	---	235
Cities Service Corp.	---	125
Coastal Chemical Corp.	---	530
Collier Carbon & Chemical Corp.	---	263
Columbia Nitrogen Corp.	---	126
Commercial Solvents Corp.	---	140
Consumer Cooperative Ass'n.	---	146
Cooperative Farm Chemicals Ass'n.	---	190
Diamond Alkali Co.	---	35
Escambia Chemical Corp.	---	80
Farmers Chemical Assoc.	---	142
Fel Tex., Inc.	---	42
FMC Corp.	---	24
Frontier Chemical Co.	---	23
W.R. Grace & Co.	---	349
Gulf Oil Corp.	---	360
Hawkeye Chemical Co.	---	136
Hooker Chemical Corp.	---	22
Ketona Chemical Corp.	---	44
Mississippi Chemical Corp.	---	113
Monsanto Chemical Co.	---	773
New Jersey Zinc Co.	---	35
Nipak, Inc.	---	224
Nitrin, Inc.	---	140

See footnotes at end of table.

Table 1.--Synthetic ammonia: Designed annual capacity 1/ of anhydrous ammonia by producer, United States, 1940 and 1966--Continued

Firm	1940 capacity	1966 capacity
	Thousand tons	Thousand tons
Northern Chemical Industries	---	40
Odessa Natural Gasoline Co.	---	127
Petroleum Chemical, Inc.	---	140
Phillips Pacific Chem. Co.	---	139
Phillips Petroleum Co.	---	646
Pittsburgh Plate Glass Co.	---	50
Reserve Oil & Gas Co.	---	21
Rohm-Hass Co.	---	50
St. Paul Ammonia Products Co.	---	90
Shamrock Oil & Gas Corp.	---	80
J.R. Simplot Co.	---	54
Smith Douglass Co.	---	40
Solar Nitrogen Chemicals, Inc.	---	272
Southern Farm Supply Assn.	---	22
Southern Nitrogen Co.	---	150
Southwestern Nitrochemical Corp.	---	40
Sun Oil Co.	---	110
Tenneco Chemical Co.	---	120
Texaco, Inc.	---	77
U.S. Industrial Chemical Co.	---	80
U.S. Steel Corp.	---	70
Valley Nitrogen Producers, Inc.	---	158
Western Ammonia Corp.	---	27
Wycon Chemical Co.	---	18
Total private	475	10,924
TVA	---	90
Total, all	475	11,014

1/ Engineering estimates.
2/ Dow Chemical Company.
3/ Olin Mathieson Chemical Corporation.
4/ Pennsalt Chemical Corporation.

Source: The firm names shown are those by which the producers are commonly known. About 40 percent of these firms are owned or controlled by other firms. Designed capacities are from published sources and may be revised as additional information becomes available (2,5,9,16,23,24).

Ammonium Phosphate

Ammonium phosphate ranks first among phosphorous end products in terms of plant capacity. Domestic capacity reached about 2.5 million tons of P_2O_5 equivalent by early 1966. In all, about 45 firms operating an estimated 50 plants were capable of producing this material.

Triple Superphosphate

Triple superphosphate ranked second to ammonium phosphate in 1966. Depending upon grade of rock and concentration of acid used, the final product contains from 40 to 54 percent available P_2O_5. Most common were grades containing either 45 or 46 percent P_2O_5.

Estimated 1966 capacity for production of triple superphosphate was nearly 4.5 million tons of material containing about 2 million tons of P_2O_5 (table 2). This includes capacities of 16 firms and the Tennessee Valley Authority; 5 of these were scheduled to commence operations in 1966.

Normal Superphosphate

Normal superphosphate, ranging from as low as 16 percent to 22 percent available P_2O_5, is widely used in mixed fertilizer as well as a separate material. However, with the rise in use of triple superphosphate and ammonium phosphates, production of normal superphosphate has declined in recent years. In 1964, 181 plants were reported making normal superphosphate in the United States (1), 37 fewer than the 218 reported for 1955, the peak year.

Potassium

About 90 percent of domestic production of potassium comes from mines in the Carlsbad, N. Mex., area. In 1965, there were six producing firms in the Carlsbad area with a seventh in production at the end of the year (table 3). Most of the remainder comes from California and Utah.

Sulfur

In the form of sulfuric acid, sulfur is extensively used by the fertilizer industry--mainly in the manufacture of phosphatic fertilizers and ammonium sulfate. During 1965, about 3.7 million tons of sulfur equivalent were consumed by U.S. fertilizer manufacturers. A major share of this material was supplied by Frasch hot-water process producers. There were only four such producers in the United States in 1966--Duval Corporation, Freeport Sulphur Company, Jefferson Lake Sulphur Company, and Texas Gulf Sulphur Company. Of these, three are integrated horizontally into the fertilizer industry. Duval, controlled by United Gas Corporation, is a potash producer in the Carlsbad area. Texas Gulf Sulphur produces potash at Moab, Utah, and phosphate rock and associated fertilizers in North Carolina. Jefferson Lake Sulphur was acquired in March 1964 by Occidental Petroleum Corporation. Occidental is also an ammonia producer and owns Occidental Agricultural Chemical Corporation, producer of Florida phosphate rock and manufacturer of phosphatic fertilizers.

Table 2.--Triple superphosphate: Designed annual capacity 1/ by producers with coexisting facilities for producing phosphoric acid, United States, 1950 and 1966

Firm	Year of initial production	1950	1966
		Thousand tons	Thousand tons
Virginia-Carolina Chem. Corp. 2/	1907	15	280
Anaconda Copper Mining Co. 3/	1920	90	4/
Tennessee Corp. 5/	1924	250	850
Armour Fertilizer Works 6/	1929	75	250
Swift & Co.	1949	30	170
Gates Brothers, Inc.	1950	40	4/
International Min. & Chem. Corp.	1952	---	500
J.R. Simplot Co.	1953	---	130
Davison Chemical Corp. 7/	1954	---	520
F.S. Royster Guano Co.	1954	---	100
Western Phosphates, Inc. 8/	1954	---	100
American Cyanamid Co.	1957	---	400
American Agricultural Chem. Co. 9/	1965	---	325
Central Phosphates, Inc.	1966	---	200
Consumers Cooperative Ass'n.	1966	---	80
El Paso Products Co.	1966	---	130
Occidental Agricultural Chem. Corp. 10/	1966	---	150
Texas Gulf Sulphur	1966	---	280
Total private		500	4,465
Tennessee Valley Authority	---	140	30
Total, all		640	4,495

1/ Engineering estimates.
2/ Mobil Chemical Co., Div. Mobil Oil Corp.
3/ The Anaconda Co.
4/ Production discontinued.
5/ U.S. Phosphoric Products Div., Cities Service Oil Co.
6/ Armour Agricultural Chemical Co.
7/ W.R. Grace & Co.
8/ Stauffer Chemical Co.
9/ Continental Oil Co.
10/ Occidental Petroleum Corp.

Sources: Designed capacities are partly from published sources (2,5,9,16, 23,24) and partly from correspondence and may be revised as additional information becomes available.

Table 3.--Potash: Designed annual capacity 1/ of K_2O by domestic producers, United States, 1950 and 1965

Firm	Year of initial production	1950	1965
		Thousand tons	Thousand tons
American Trona Corp. 2/	1916	100	280
American Potash Co. 3/	1931	350	500
Potash Company of America	1934	425	600
Bonneville, Ltd. 4/	1938	50	100
Union Potash Co. 5/	1940	375	400
Duval Corp.	1952	---	340
Southwest Potash Co.	1952	---	600
National Potash Co.	1952	---	330
Texas Gulf Sulphur Co.	1964	---	6/360
Kermac Potash Co. 7/	1965	---	8/---
Miscellaneous		15	15
Total		1,315	3,525

1/ Engineering estimates.
2/ American Potash and Chemical Corp.
3/ U.S. Borax & Chemical Corp.
4/ Kaiser Aluminum & Chemical Corp.
5/ International Minerals & Chemical Corp.
6/ Initial output late 1964.
7/ Owner: 50 percent Kerr-McGee Oil Industries, 50 percent National Farmers Union Development Corp.
8/ Initial output in November 1965. Annual rated capacity 550,000 tons when in full production.

Sources: Designed capacities are partly from published sources (2,5,9,16,23,24) and partly from correspondence and may be revised as additional information becomes available.

Marketing and Distribution Channels

Distribution channels for the plant nutrients are highly complex. The distribution scheme shown in figure 1 is greatly simplified. Earlier marketing patterns approached classical lines: Raw-materials producers sold only to fertilizer mixers, mixers sold only to retail dealers, and retail dealers sold to consumers. But links in this chain weakened and some disappeared. Perhaps only 25 percent of the fertilizer reached consumers through traditional channels in 1964.

Faced with highly seasonal demand, many producers of primary nutrients have warehouses throughout the country, particularly in the Midwest. Warehousing in market areas reduces risks in depending on barge or rail delivery at the height of the shipping season, since the nutrients are immediately available. Delivery from local warehouses is usually by truck. In this way, the storage function and associated costs are shifted from the mixing plant to the raw-materials supplier. In turn, the supplier has reduced need for warehousing at the plant and has shifted it to the field. Because

Domestic Fertilizer Distribution Channels

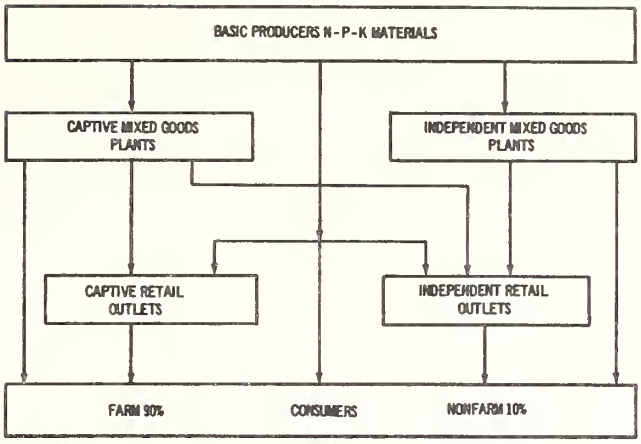

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Figure 1

transportation costs are high--25 percent or more of the retail price--producers are likely to trade more among themselves in the future.

During the first half of this century, the superphosphate manufacturer, usually a fertilizer mixer at the same time, was the backbone of the fertilizer distribution system. These firms were equipped to serve an area within a radius of 200 to 300 miles. Beyond this distance, freight costs became excessive. Such plants represented relatively large capital investments, not only in machinery and equipment but also in storage capacity and inventory costs. Fertilizer use is extremely seasonal and the vast bulk of sales were, and are, made in 2 or 3 months during the spring. During much of the year, mixers produced fertilizer for storage, as well as for curing, to meet spring demand. Annual tonnages of typical mixing plants covered a wide range, from 10,000 to 50,000. Larger plants probably were more efficient since they were in a position to take advantage of both internal and external economies of scale.

Capital investment in a mixing plant capable of producing 50,000 tons annually of fertilizer with an average plant nutrient content of 30 percent could be in the neighborhood of $600,000 or more. In addition, with 30,000 tons of finished goods in storage awaiting shipment in February, March, and April, inventory investment alone might be over $1 million.

Mixing Plants

The United States in 1952 had an estimated 1,225 fertilizer mixing plants, ranging from 119 with annual capacity under 1,000 tons to 12 with capacities of 200,000 tons and over (17). Together, they could produce nearly 26 million tons of material

each year. About half of this capacity was located on the eastern seaboard in States from New York to Florida.

Fertilizer mixing plants doubled in number to an estimated 2,500 by 1963. At the same time, the concentration of facilities shifted from the Southeast to the Midwest. For example, in 1952 there were 358 mixing plants in Georgia, North Carolina, South Carolina, and Virginia. By 1963, because of consolidations and plant closings, only 266 mixing plants were located in these same States, while the number of plants (including bulk-blending plants) in Ohio, Indiana, Illinois, Iowa, and Missouri jumped from 135 in 1952 to almost 1,000 in 1963.

Bulk Blending and Delivery

Bulk blending and bulk delivery have moved into many parts of the country, especially the Midwest. Since about 75 percent of all fertilizer mixing plants have bulk loading facilities, it is difficult to identify so-called "bulk blenders" with certainty. Loosely, a bulk blending plant may be defined as a plant serving a radial area of perhaps 25 miles, with limited capital investment--up to $100,000 or more but more typically $50,000 or less--with one to five full-time employees, and with its profit break-even point at about 3,000 tons of fertilizer. Such plants increased from around 700 in 1962 to near 2,600 in 1965 (20).

A major factor in the increase in bulk blending has been the adaptation of State codes by fertilizer control officials to this method of marketing fertilizers, resulting in the ability of mixers to sell users the grades they demand. Soil testing is an important service that enables the firm to blend the type of fertilizer needed on each field or pasture.

Liquid Mixtures

The number of firms producing liquid fertilizer mixtures is expanding sharply. In 5 years, 1959 to 1964, the number of such plants more than doubled from about 330 to slightly more than 700 (20).

Consumption of liquid mixed fertilizers increased from 27,500 tons in 1954 to 782,000 tons in 1963 in the 48 States (20). As with blended fertilizers, the region of greatest growth was the Midwest. Over 500,000 tons of liquid mixed fertilizers were consumed in the North Central States in 1963, compared with 2,300 tons in 1954.

Slurries

Closely allied with clear liquid mixes are so-called "slurries." These products, more viscous than clear liquids, consist of exceedingly fine particles of the nutrient materials held in suspension in a liquid. Suspensions were developed in an effort to provide liquid fertilizers of higher grades than could be obtained with clear liquids.

Farmer Cooperatives

Farmers have a sizable stake in the fertilizer industry through farmer-owned cooperatives. These have emerged as a significant factor in at least two segments of the industry--synthetic anhydrous ammonia production and retail distribution.

As of January 1, 1966, cooperatives owned 11 ammonia plants with an estimated annual capacity of 1.5 million tons of anhydrous ammonia (table 4), about 14 percent of total domestic capacity. However, the cooperatives' share of the farm market probably was greater than 14 percent since most cooperative production was used as fertilizer while a portion of the output from other plants was diverted to industrial uses.

At the retail level, cooperatives are handling an increasing proportion of the fertilizer farmers buy. According to recent estimates, net fertilizer sales of 4,409 cooperatives were $507 million in the 12 months ended June 30, 1965 (19), nearly 30 percent of total farm fertilizer sales in the United States, compared with 15 percent in 1951 and 9 percent in 1943.

Largely responsible for the upswing in total national sales by cooperatives was a strong rise in fertilizer use in the Midwest. Cooperatives, well established in the area by the 1950's, were logical outlets for fertilizer. Many regional cooperatives own fertilizer mixing plants, blending plants, anhydrous ammonia applicators, and so on. Through contractual arrangements with basic manufacturers as well as outright ownership of productive facilities, cooperatives are effectively organized. They have emphasized high-analysis fertilizers, bulk blending based on soil tests, and bulk spreading to save farmers time and labor.

Table 4.--Cooperative plants producing synthetic anhydrous ammonia Jan. 1, 1966, United States 1/

Firm	Plant location	Anhydrous ammonia estimated designed annual capacity 2/
		Thousand tons
Central Nitrogen, Inc.	Terre Haute, Ind.	123
Coastal Chemical Corp.	Pascagoula, Miss.	180
	Yazoo City, Miss.	350
Consumers Cooperative Assoc.	Hastings, Nebr.	146
Cooperative Farm Chemicals Assoc. 3/	Lawrence, Kans.	190
Farmers Chemical Assoc.	Tyner, Tenn.	142
Fel Tex, Inc. 4/	Fremont, Nebr.	42
Mississippi Chemical Corp.	Yazoo City, Miss.	113
St. Paul Ammonia Prod. Co. 5/	Pine Bend, Minn.	90
Valley Nitrogen Prod. Inc.	Helm, Calif.	158
Southern Farm Supply Assoc.	Amarillo, Tex.	22
Total capacity		1,556

1/ Excludes Alaska and Hawaii.
2/ Engineering estimates.
3/ Owned by Consumer Cooperative Assoc.--75 percent; Missouri Farmers Assoc.--25 percent.
4/ Owned by Farmers Regional Cooperative, Ft. Dodge, Iowa.
5/ Under a contractual arrangement with Central Farmers Fertilizer Co., Chicago.

Source: See table 1.

Changing Structure of the Fertilizer Industry

As the fertilizer industry changed to complex, advanced chemical processes, firms with necessary technical skills emerged as industry leaders. Integration--vertical, horizontal, forward, and backward--has accompanied the technological revolution in the industry.

Among phosphate rock producers, for example, as recently as 1950, International Minerals and Chemical Corporation was the only firm supplying both phosphate rock and potash. This company also operated mixing plants as did most phosphate rock producers. Smith Douglass Fertilizer Company, one of two firms that were both ammonia producers and fertilizer mixers, in 1952 acquired Coronet Phosphate Company, a Florida pebble rock phosphate producer. With this acquisition, most of the phosphate rock for domestic fertilizer was produced by American Agricultural Chemical Company, American Cyanamid Company, Armour Fertilizer Works, Davison Chemical Corporation, International Minerals and Chemical Corporation, Smith Douglass Fertilizer Company, and Virginia-Carolina Chemical Corporation. Of these, only American Cyanamid was not deeply involved with mixing plants.

However, by 1965, Virginia-Carolina was merged with Mobil Oil Corporation, American Agricultural Chemical Company had become a part of Continental Oil Company, Smith Douglass was purchased by Borden Company, and Davison was bought by W.R. Grace and Company. Although they were not mining in 1965, Tennessee Corporation, a subsidiary of Cities Service Oil Company, also owned phosphate rock reserves in Florida.

Further moves toward complete integration at the raw materials level were made by the so-called "old-line" fertilizer producers. By 1965, International Minerals had become a producer of ammonia through co-ownership with Northern Natural Gas Company of Nitrin, Inc., an anhydrous ammonia plant. Armour owned two ammonia plants and was co-owner with Pittsburgh Plate Glass of Kalium Chemicals, Ltd., a Canadian potash producer. Swift together with Skelly Oil Company owned Hawkeye Chemical Company, an ammonia producer, as well as a fifth interest in a Canadian potash mine with Homestake Mining and U.S. Borax and Chemical Company as co-owners of the remaining shares.

As in the phosphate rock industry, the difficulty of acquiring a commercially exploitable deposit of potash is a barrier to entry. Known domestic deposits are limited in extent. A vast reserve of ore was discovered in 1943 in Saskatchewan, Canada, and development began in 1952. Production began in 1958 by Potash Company of America but was halted in 1959 when water seepage forced closing of the mine. International Minerals began operations in 1962 and Potash Company of America resumed output in 1965. As quality of Carlsbad, N. Mex., ore decreases, more emphasis will be given to Canadian reserves. Each of the domestic producers has obtained reserves in Canada. Of these, only two were in production in the first half of 1965. A third producer, Kalium Chemicals (owned jointly by Armour and Company and Pittsburgh Plate Glass Company), is now making shipments. Other shafts are being sunk, and about 25 firms have acquired rights to potash deposits in Canada.

North American producers have an aggregate capacity of more than 5.5 million tons, K_2O equivalent, of potash. Domestic capacity of the nine major producers is over 3.5 million tons and the Canadian capacity of the three producing firms is about

1.9 million tons. Estimated total capital investment in North American productive facilities is more than $500 million, based on a replacement cost of $100 per annual ton of K_2O.

Synthetic ammonia productive capacity and use (about three-fourths of the output goes to fertilizer) has increased sharply since World War II. From a level of 1.5 million tons in 1945, rated plant capacity rose to 11 million tons annually by the beginning of 1966. At that time, 65 firms operated 89 plants. Public announcements indicate that capacity will jump sharply to about 18 million tons by 1969--a 64-percent increase over 1966.

Accompanying the dramatic rise in ammonia productive capacity has been the entry, through purchase, merger, and other arrangements, of petroleum products producers into the field of chemical fertilizers. As of 1966, petroleum industry firms owned or controlled nearly 40 percent of the total capacity for ammonia. The entry of these firms into the fertilizer industry represents the introduction of large new resources in the form of financial capital, and perhaps more important, technical and marketing skills.

Indicative of recent moves toward diversification and integration in the synthetic ammonia industry are data cited by a leading authority in fertilizer marketing (20, p. 36). These data suggest that expansion of the nitrogen industry from 1960 to 1965 was distributed about as follows:

(Fertilizer) Companies integrating back	46%
Companies in the nitrogen business expanding	27%
New integrated producers	18%
New merchant producers	9%

Foreign Trade

In the year ended June 30, 1966, the United States was a net exporter of phosphate rock, phosphatic fertilizers, and nitrogen, and a net importer of potash.

With investment of U.S. capital for development of the Canadian potash reserves, imports of this material will continue to rise. High freight rates from Carlsbad to the east coast enable European producers--German and French--to sell considerable tonnages of potash in this country.

Phosphate rock exports exceed imports by a considerable margin. About 40 percent of our rock production, P_2O_5 content basis, is exported. Imports are on the order of 200,000 long tons.

Recent reports indicate that in 1964 North American plants had the capacity to produce 27 percent of the world's nitrogen supply, and about 35 percent of both P_2O_5 and K_2O (20). Western Europe can produce 36 percent of the total nitrogen and one-third each of P_2O_5 and K_2O. Roughly a third of the world capacity of each of the plant nutrients is located in regions other than North America and Western Europe.

Looking Ahead

Growth of the fertilizer industry is closely allied with a continuing and expanding program of research and development. Public agencies and manufacturers continually seek new fertilizer materials, new technologies, new ways to produce and market fertilizers, and new methods of using plant nutrients to increase crop output.

Private industry research is oriented toward locating and developing new deposits of phosphate rock and potash minerals, fixing atmospheric nitrogen at lower unit cost, and improving the quality of fertilizers. At every stage of manufacture and use, methods of reducing handling and shipping costs are sought.

Part of the research cost associated with the development of new fertilizers and new production techniques is borne by the Federal Government at the National Fertilizer Development Center, Tennessee Valley Authority. Related research in the U.S. Department of Agriculture and in the State agricultural experiment stations is centered on the science of plant nutrition.

An Expanding Industry

Relatively firm commitments for expansion or new construction of synthetic anhydrous ammonia plants indicate that total U.S. productive capacity will be about 17 million tons by January 1, 1968, in contrast to an estimated capacity of 7.6 million tons available at the beginning of 1964. How the market reacts to increased supplies of nitrogen in the coming 2 or 3 years will determine what happens thereafter.

Development of the North Carolina phosphate rock fields in combination with operations in Florida and the Western States suggests an ample supply of phosphate rock for a considerable period.

The sulfur supply is limited and although new domestic deposits are being sought, they are slow to come into production. As a consequence, some manufacturers are experimenting with other acids such as nitric or hydrochloric. Also, facilities for producing phosphoric acid without the use of sulfuric acid may be greatly enlarged.

These processes, and others not yet out of the laboratory, undoubtedly will become more prominent in the years ahead.

If the current tight sulfur supply situation is not eased, some maldistribution of fertilizers made with sulfuric acid may occur at the height of the planting season in the next few years. However, sulfur producers anticipate that the sulfur supply will expand to meet demand within 3 to 5 years. If the prices of sulfur and sulfuric acid continue to rise, some manufacturers may shift to phosphate fertilizers made with nitric acid instead of sulfuric. Nitric phosphates have been made in Europe for many years and satisfactory processes have been developed. A move to nitric phosphates will be even more likely if costs of producing nitric acid, made with low-cost ammonia, are reduced.

Discovery and successful exploitation of Canadian potash reserves assures an ample supply for a long time, even at increased rates of consumption. The Saskatchewan ore body is believed to be the richest in the world and exceeds known domestic reserves by an estimated 70 to 100 times.

Demand for fertilizer is rising sharply. Domestic consumption of plant nutrients by 1980 may easily be twice what it was in 1965. The long upward trend in average plant nutrient content of fertilizer will continue as highly concentrated fertilizers are more widely used.

Major contributions to growth in the immediate future will be made by producers of ammonium phosphates and superphosphoric acid as these products increase in importance. Still in the early stages of development but showing great promise are the polyphosphates. Production of fertilizers with polyphosphate bases is almost sure to rise, perhaps sharply as technology advances.

The quality of fertilizers will continue to be upgraded. The preparation of solid fertilizers that are granulated is likely to approach the 90-percent level within 5 years or so. Consumption of bulk blended fertilizers will continue to rise and use of fluid fertilizers also will grow.

Crop yields, enhanced by liberal applications of primary nutrients, may be limited by deficiencies in micro and secondary nutrients. Ways to include carriers of these materials in fertilizers will be improved as demand for micronutrients strengthens.

Within most class and grade categories of plant nutrients, the products of different manufacturers are close substitutes. As a consequence, major competition centers on product condition, prices, and services. To gain a competitive advantage, channels of distribution will tend to be shortened as some basic producers deal directly with users through company-owned outlets.

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NOTE 4--CHEMICAL PESTICIDES 1/

by

Austin Fox 2/

The Present Setting

Pest control is important in the production of nearly all farm commodities. Efficient production of crops and livestock requires careful use of chemicals and other means for control of agricultural pests. However, insects, plant disease organisms, nematodes, weeds, rodents, and other pests continue to plague us.

Recent cropping practices and increased crop concentrations have created an environment ideally suited for many plant pests. Mechanical, cultural, and biological controls have not been sufficient, though cultural methods have been improved and many resistant crop varieties have been developed. Yet, these pest control methods supplemented with chemical pesticides provide reasonably good protection. The objective of much of the current research on pest control is to develop nonchemical methods. Still it is likely that chemicals will continue to be the principal method of control for some time to come.

Beginning with DDT during World War II, a number of synthetic organic compounds have been discovered and developed that are highly toxic to many disease organisms, insects, and weeds and are effective in controlling them. Three principal kinds of chemical pesticides are used by farmers--insecticides, herbicides, and fungicides. For these and other chemical pesticides, it is estimated that farmers spent $514 million in 1964, nearly twice as much as in 1960 (1). 3/

Insecticides

Historically, insecticides have accounted for the largest share of the farm chemical pesticides used (table 1). 4/ Their use continues to increase, but they now make up a smaller share of the total because of the rapid rate of increase in the use of herbicides. At the end of World War II, insecticides made up about 60 percent of total farm chemical pesticide sales. 5/

1/ In this report, "chemical pesticides" are broadly defined as all agricultural chemicals except those materials used as fertilizers, feed additives, and medicinal preparations.

2/ Austin Fox is a member of the Production Resources Branch, Farm Production Economics Division, Economic Research Service.

3/ Underscored numbers in parentheses refer to Selected References, page 53.

4/ Data in table 1 are derived from the Census of Manufactures. The latest census was for 1963. Data from other sources suggest that indicated trends are continuing.

5/ Based on value of shipments and including interplant shipments (10).

Table 1.--Changing composition of shipments of agricultural pesticides, United States, 1954 and 1963

Item	Percentage of total	
	1954	1963
	Percent	Percent
Insecticides	62.7	52.6
Herbicides	17.0	22.1
Fungicides	14.2	10.1
Miscellaneous and unclassified 1/	6.1	15.2
Total	100.0	100.0

1/ Miscellaneous includes agricultural chemicals not elsewhere classified, such as soil fumigants, soil conditioners, disinfectants, and animal dips. Unclassified includes agricultural pesticides and other agricultural chemicals not specified by kind, mainly insecticides, herbicides, and fungicides from small producers who were not required to report materials separately.

Source: Constructed from information in table 5 in the Pesticide Situation for 1964-65 (10) which was derived from the 1963 Census of Manufactures.

Pre-World War II insecticides were mainly arsenates, petroleum emulsions, and rotenone. Since then, synthetic organic substitutes have captured nearly the whole insecticide market. Two classes of organic insecticides, chlorinated hydrocarbons (including DDT, aldrin, chlordane, dieldrin, heptachlor, and toxaphene) and organic phosphorus compounds (including malathion and parathion) have been largely responsible.

Herbicides

Agricultural chemicals have long been used by farmers for control of insect pests and fungus diseases. Beginning in the early 1940's with 2,4-D, a chemical that selectively kills broad-leaved plants, a new concept in weed control has developed. By use of proper herbicides, mechanical tillage of many crops has been reduced or eliminated. Herbicides accounted for 22 percent of the farm pesticide market in 1963, and are likely to form a considerably larger share in the future (10). Some of the increase in chemicals included in this category will come from expanded use of mechanical harvesting methods that require growth regulators, desiccants, or defoliants for proper operation of the machinery.

Fungicides

Fungicides have declined in relative importance in the pesticide market even though the quantity used has more than doubled in the last 20 years. In 1963, fungicides accounted for one-tenth of the chemical pesticides used on farms (10). Synthetic organic fungicides are replacing and supplementing inorganic materials. In terms of dollar sales, about three-fourths of the fungicides sold are synthetic organic materials.

The Industry Structure

Chemical pesticides, before they are ready for use, generally pass through at least two production stages. First, basic technical chemicals are manufactured from raw materials. Then, these toxic chemicals are blended or formulated into a finished product for packaging and shipment through distribution channels.

Basic Chemicals Production

In 1964, 106 firms operating 169 plants produced nearly all the basic pesticide chemicals.6/ More than half of the plants were located in six States--New Jersey (30), California (18), Illinois (12), New York (11), West Virginia (9), and Texas (9) (table 2). A number of these firms are among the largest businesses in the country and are well diversified (table 3). About 30 of these companies also produce basic fertilizer materials and many make chemicals for general use.

Of the 106 companies that manufactured basic pesticide chemicals, about three-fifths produced technical materials for only one of the three kinds of pesticides (fungicides, herbicides, or insecticides), about a fourth produced materials for two kinds, and an eighth made materials for all three kinds (table 4). Also, many firms were sole producers of a single product material. Sometimes several companies produced the same material. For example, DDT, first of the current generation of major organic pesticides produced in this country, was made by eight firms in 1964--Allied Chemical Company, Diamond Alkali, FMC Corporation, Geigy Chemical Company, Lebanon Chemical Corporation, Montrose Chemical Company, Olin Mathieson Chemical Corporation, and Stauffer Chemical Company. On the other hand, dieldrin was made only by Shell Chemical Company. The top four companies (in terms of dollar volume of sales) produced about 50 percent of the total pesticides. However, production of pesticides accounts for only about 5 percent of the total output of synthetic organic chemicals.

At the manufacturer's plant or warehouse level, shipments of unformulated pesticide chemicals in 1964 amounted to about $244 million. This total excludes intraplant transfers of technical chemicals primarily for formulation. About half of the producers of basic chemicals were also formulators or distributors.

The synthesis of organic pesticides is a relatively new branch of chemistry and is still in the exploratory stage. Research costs are high. One estimate is that only 1 in 1,800 new compounds reaches the retail market. The time lapse between first experimentation and a marketable product is said to average 2 to 5 years (5). High costs usually limit research, discovery, development, and production of new chemical pesticides to firms with large financial resources.

6/ Estimated from materials in (8, 16, 18) and from information provided by Harold H. Shepard, ASCS, U.S. Dept. Agr. The 169 plants do not include home offices unless a plant is located there.

Table 2.--Number of plants producing basic pesticide chemicals, and number of plants formulating and distributing commercial pesticide products, by States and regions, United States, 1964 1/

State and region	Plants producing basic pesticide chemicals	Plants formulating and distributing
	Number	Number
Maine	---	4
Massachusetts	1	15
Connecticut	1	9
New York	11	73
New Jersey	30	59
Pennsylvania	8	39
Delaware	---	2
Maryland	2	20
Northeast	53	221
Michigan	6	28
Wisconsin	1	35
Minnesota	1	38
Lake States	8	101
Ohio	7	44
Indiana	3	34
Illinois	12	104
Iowa	1	52
Missouri	6	69
Corn Belt	29	303
North Dakota	---	6
South Dakota	---	1
Nebraska	1	33
Kansas	3	28
Northern Plains	4	68
Virginia	2	15
West Virginia	9	3
North Carolina	1	35
Kentucky	3	10
Tennessee	4	26
Appalachian	19	89
South Carolina	1	36
Georgia	4	65
Florida	---	102
Alabama	6	34
Southeast	11	237
Mississippi	4	24
Arkansas	2	14
Louisiana	3	34
Delta States	9	72
Oklahoma	---	9
Texas	9	74
Southern Plains	9	83
Montana	---	1
Idaho	---	8
Wyoming	---	2
Colorado	3	36
New Mexico	---	10
Arizona	---	26
Utah	---	2
Nevada	2	2
Mountain	5	87
Washington	2	55
Oregon	2	32
California	18	194
Pacific	22	281
United States	169	1,542

1/ No plants reported in New Hampshire, Vermont, and Rhode Island. Information for Alaska and Hawaii not available.

Source: See footnote 6, page 44.

Table 3.--Basic producers of agricultural chemical pesticides, United States, 1964 1/

Abbott Laboratories
Alco Chemical Corp.
Allied Chemical Corp.
Amchem Products, Inc.
American Cyanamid Co.
American Fluoride Corp.
American Potash and Chemical Corp.
Ansul Chemical Company
Arapahoe Chemicals Inc.
Baldwin-Montrose Chemical Co., Inc.
J.H. Baxter and Company
Benzol Products Company
Buckman Laboratories, Inc.
California Chemical Co.
California Sulphur Company
Calumet and Hecla, Inc.
Carlisle Chemical Works Inc.
Chemagro Corp.
Chemical and Pigment Company
Chemical Insecticide Corp.
Chemley Products Company
Chipman Chemical Co., Inc.
W.A. Cleary Corp.
Cockerille Chemicals, Inc.
Commercial Solvents Corp.
Corona Chemical Company
Dawson Chemical Co.
Diamond Alkali Company
Douglas Chemical, Inc.
Dow Chemical Company
E.I. du Pont de Nemours and Company
Eli Lilly and Company
Ethyl Corp.
Fairfax Biological Chemicals
Fairfield Chemicals
Ferro Corporation
Gamma Chemical Corp.
Geigy Chemical Corp.
General Aniline and Film Corp.
Great Lakes Chemical Corp.
Guard Chemical Co., Inc.
Gulf Oil Corp.
Guth Chemical Co.
Harshaw Chemical Co.
Hercules Powder Co., Inc.
Hooker Chemical Corp.
Humble Oil and Refining Corp.
Imperial Chemical Company, Inc.
International Minerals and Chemical Corp.
Kolker Chemical Corp.
Lebanon Chemical Corp.
Mallinckrodt Chemical Works
McLaughlin, Gormley King Co.
Merck and Co., Inc.
Metalead Products Corp.
Metalsalts Corp.
Michigan Chemical Corp.
Millmaster Chemical Corp.
Mobil Oil Corp., Mobil Chem. Co.
Mobil Oil Corp., Virginia-Carolina Chem. Co.
Monsanto Chemical Company
Montrose Chemical Corp. of California
Morton Salt Co.
Motomco, Inc.
Niagara Chemicals
Olin Mathieson Chemical Corp.
Organic Chemicals
S.B. Penick and Co.
Pennsalt Chemicals Corp.
Phelps Dodge Refining Corp.
Pierce Chemical Co.
Pittsburgh Plate Glass Co.
Prentiss Drug and Chemical Co., Inc.
Reichold Chemicals, Inc.
Riverdale Chemical Co.
Roberts Chemical, Inc.
Rohm and Haas Company
Sherwin Williams Co.
Shell Oil Company
Spencer Chemical Co.
Standard Chlorine Chemical Co., Inc.
Standard Oil of California
Stauffer Chemical, Calhio Chem. Div.
Stauffer Chemical Co.,Industrial Chem.Div.
Stecker Chemicals Inc.
Fred'k A. Stresen-Reuter Inc.
Tenneco Chemicals
Tennessee Corp.
Thompson Chemicals Corp.
Thompson-Hayward Chemical Co.
Triangle Chemical Co.
Troy Chemical Co.
Tull Chemical Co., Inc.
Union Carbide Uniroyal Corp.
Universal Oil
U.S. Borax and Chemicals Corp.
Upjohn Company
Vanderbilt Chemical Corp.
Velsicol Chemical Corp.
Vineland Chemical Company
Virginia Chemical and Smelting Co.
Vulcan Materials Company
Witco Chemical Co., Inc.
Woodridge Chemical Corp.
Woolfolk Chemical Works Ltd.

1/ See footnote 6, page 44.

Table 4.--Number of producers of basic chemicals used to manufacture pesticides, by kind of pesticide, United States, 1964

Basic chemicals for--	Producers
Fungicides only	23
Herbicides only	19
Insecticides only	23
Fungicides and herbicides	9
Fungicides and insecticides	9
Herbicides and insecticides	9
Rodenticides only	1
Total	106

Source: See footnote 6, page 44.

Pesticide Formulation

Basic technical chemicals are too concentrated for field application immediately from the production line. Thus, either the technical chemical or a concentrate of it is shipped to other firms for further preparation. These firms, known as formulators, mix concentrated chemicals with dry diluents, solvents, emulsifiers, and other substances to assure stability, reduce concentration, improve handling, and, in many instances, enhance effectiveness of the final product. Many formulations contain more than one active ingredient. More formulating plants are independently owned than not; however, about a half of the primary producers also formulate.

The pesticide industry is closely allied with the petroleum industry. The hydrocarbon chemicals, from which a large share of synthetic organic chemical pesticides are produced, are largely petroleum derivatives. In addition, the solvents used to produce liquid pesticide emulsions are petroleum products.

Most commonly, pesticide formulations are dusts, wettable powders, and emulsions. Dusts are made with clays, talcs, and similar materials. Immediate toxicity varies inversely with particle size; the quantity of diluent may average several times as much as the toxic agent. A typical field-strength dust may contain 2 to 5 percent effective toxicant. However, some mixtures consisting of more than one pesticide may contain no carrier material.

Wettable powder formulations are similar to dusts. However, the active ingredient content is markedly higher, ranging up to 50 and, more rarely, 75 percent. Wettable powders are mixed with water at time of use. The water is the carrier of the pesticide. Difficult problems may arise in formulation of toxic materials because of the varying chemical composition of the water used.

Emulsions are fast becoming the most popular form in which pesticides are formulated. An emulsion is a dispersion of fine particles of a liquid in a liquid. The toxicant is dissolved in an organic solvent with an emulsifying agent to keep the chemicals evenly distributed throughout the mixture. As with wettable powders, a wetting agent must be added to increase spreading and penetrating power of the liquid mixture.

Approximately 1,600 formulating plants are in the 48 contiguous States (8). Most of these plants are relatively low-cost installations with simple mixing and blending equipment. They serve a limited area surrounding the plant and their output is patterned to local conditions. Sales average $350,000 annually per plant.

Pesticide formulation is as seasonal as the type of farming the plant serves. Many plants operate less than 6 months a year. For this reason, formulators have often diversified into other businesses, or other businesses have diversified into formulating. Many firms offer a broad array of farm services to complement their activities as formulators.

Only 240 firms with 340 plants of the 1,600 plants operating in 1963 formulated and prepared commercial pesticide products as their major enterprise (15). Employment at these plants averaged 16 production workers each at an annual wage of $4,600 or $2.30 per hour. Production workers accounted for 58 percent of all employees. About two-thirds of the plants had fewer than 20 employees each. Total employment in these 340 plants reached 9,090 in 1963, and all employees received nearly $51 million in wages and salaries.

Marketing and Distribution Channels

The market for pesticides is composed of three broad categories of consumers. They are: farmers--40 percent; institutional, industrial, and residential users--40 percent; and exports--20 percent. Channels of distribution are indicated in figure 1. Shipments by formulators to these users amounted to about $630 million in 1964. Shipments made by basic producers directly to consumers, estimated at $70 million, bring the aggregate 1964 value of pesticides produced to about $700 million at the formulator's price level. Thus, at the retail price level, sales of pesticides currently may be as high as $1.5 billion. Farm use alone was estimated at $514 million in 1964 and $519 million in 1965.7/ To a large extent, export and institutional-industrial markets are supplied directly by manufacturers, bypassing intermediate distributors.

More than 10,000 pesticide products packaged under about 450 company labels were available for use in the United States in 1964 (3). Just over half of these 450 companies sold 7 or fewer products, 50 sold 50 or more, and of these 20 sold 100 or more. Of the five firms that sold the largest number of pesticide products (Chevron Chemical Company, Chipman Chemical Company, Florida Agricultural Supply Company, Kilgore Seed Company, and Stauffer Chemical Company) each sold 180 or more different preparations.

At the local level, urban consumers obtain pesticides from a wide assortment of retail outlets including garden supply centers, department stores, supermarkets, and hardware stores. Farmers, too, often patronize these suppliers for incidental purchases of household and garden pesticides.

Farmers most often buy pesticides at general farm supply stores, at feed, fertilizer, and machinery dealers, and at local grain elevators. They may also buy pesticides directly from formulators who provide a variety of farm services, or from specialized custom applicators.

7/ Sales of pesticides in 1964 are reported in (1); those for 1965 were estimated by the author from unpublished data in the Farm Production Economics Division, ERS.

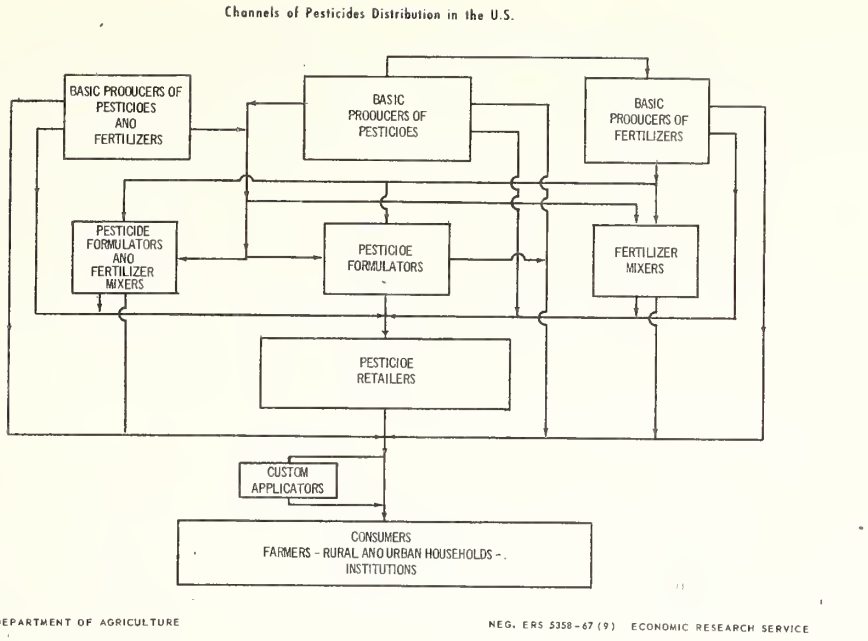

Figure 1

Farmer cooperatives play an important part in the pesticides industry, although they have not entered the business as primary producers. However, they own approximately 30 formulating plants scattered throughout the country. With the output from these plants and with materials bought from other suppliers, slightly over 3,000 cooperative outlets retailed pesticides valued at nearly $80 million in 1965 (12), about 15 percent of farm expenditures for pesticides.

Ownership of local outlets is largely dependent upon the competitive philosophies of the individual basic producing firms. Some believe that independent merchants can best serve the needs of farmers and so they try to strengthen their franchised dealers. Others emphasize company ownership or leasing of retail facilities to maintain full control of merchandising. Testing the relative merits of alternative methods of distribution began in earnest a decade ago. At that time, a shift to close control of retail outlets by some basic producers was spurred by a number of newcomers to the farm chemical industry. Among these were firms in the petroleum industry. With ample financial resources, they were able to buy, build, or lease retail outlets. To maintain their competitive position, established manufacturers of production inputs followed suit. Many "country store" dealerships were upgraded, modernized, and staffed with trained personnel. Some independent dealers through their own initiative were forerunners in adding new lines to provide more complete, fast, efficient service to their customers.

Foreign Trade

Exports of pesticides in 1964 were valued at $135 million (10). The major customers for U.S. pesticides were Canada, Mexico, Japan, and Colombia. Shipments

to these four countries amounted to more than $38 million. During the first 6 months of 1965, technical chemicals accounted for 56 percent of pesticide exports and formulated preparations the balance.

Imports of synthetic organic pesticides--principally from the United Kingdom, West Germany, Denmark, and Japan--amounted to $2.1 million in 1964. Some shipments to this country are for the purpose of testing the American market for new products; others are in competition with U.S. production. In addition to synthetic or organic chemicals, botanical derivatives such as rotenone, nicotine, and pyrethrum were shipped to U.S. destinations. Imports of pyrethrum alone came to $5.2 million in 1964. Total pesticide imports probably amounted to less than $10 million.

Consumer Safeguards

Public awareness of potential hazards that exist with increasingly widespread use of chemical pesticides is evidenced by both Federal and State legislation.8/ Protection of ultimate consumers against pesticides in food supplies and other products was provided with enactment of the Federal Food, Drug, and Cosmetic Act of 1938. Among other things, this Act establishes amounts of chemical residue permissible in treated crops when harvested. It was updated and expanded in 1954 and 1960.

The Federal Insecticide, Fungicide, and Rodenticide Act of 1947 is another basic pesticide law. This Act requires registration of pesticides with the U.S. Department of Agriculture. Such registration must show composition of the product and its proposed labeling. When requirements of the Act are met, a registration notice is issued. Pesticide users are protected against personal injury or economic loss by provisions of the Act which prohibit adulteration or misbranding of registered products. The Act was expanded in 1959 and amended in 1964 and 1965.

In addition to Federal regulation, all 50 States have enacted laws regulating pesticides. Without exception, pesticide products must be registered in each State where their sale is intended. Registration procedures generally are similar to those of the U.S. Department of Agriculture.

As types and numbers of chemical pecticides have increased, their regulation has tended to become more stringent. Allowable residues (tolerances) are continually scrutinized and reevaluated. Some compounds may be removed from the market when equally effective and less hazardous substitutes are found.

Research and Development

The future of the chemical pesticides industry hinges on new product research and development. During the decade from 1950 to 1960, total research expenditures on pesticides--private and public--rose at an average rate of about 8 percent a year. In the early 1960's, however, the rate began to soar. One estimate put total 1962 pesticide research expenditures at $63 million--$33 million of private funds and $30 million of public funds (6). The upward trend has continued. In fiscal 1964, such outlays of public funds were estimated at about $48 million (17). Of this amount, the

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8/ A complete listing and some explanation of the legislation to date is given in a 1966 Senate Report (17, pp. 69-86).

U.S. Department of Agriculture spent $37 million, or about three-fourths of the total. The Department of the Interior and the Department of Health, Education, and Welfare accounted for most of the remainder. From 1964 to 1965, there was a further increase of about 60 percent in Federal expenditures for pesticide research. Federal expenditures are continuing to rise but at a slower pace. The increase from 1965 to 1966 was only about 4 percent.

USDA research emphasizes improvements in conventional chemicals. It seeks ways of applying them to reduce pesticide residues, of developing and improving biological, physical, cultural, and other methods of control, and of breeding resistant plants and animals. Funds are also directed toward expanding basic knowledge of biology, ecology, physiology, and biochemistry with hope of establishing new, fundamental principles of pest control.

Weed control researchers seek and develop selective herbicidal materials; they investigate methods of application that avoid or minimize residues in the environment. Insect control specialists are giving increasing attention to the development of highly selective and less persistent insecticides, use of sterility techniques, and sex and food attractants and repellents. Biological research is being stressed as scientists look for methods of control that utilize insect parasites, predators, and disease organisms. The U.S. Department of Agriculture allocated about 40 percent of its 1966 research funds for pest control to biological and genetic studies.

Much of private industry's research is oriented toward finding more selective pesticides. Research workers are looking for chemicals that will control harmful insects without disturbing their natural predators. Research in herbicides points toward expanding use of pre-emergence chemicals. Considerable effort also is devoted to the discovery of new systemic pesticides and refinement of existing ones.

Each year, industrial laboratories screen between 40,000 and 60,000 different compounds synthesized specifically for pesticide use. Because of their highly technical nature and high cost, nearly all the synthetic organic pesticides now in commercial use were synthesized by private firms in the industry itself.

Looking Ahead

As indicated above, research on pesticides is likely to continue increasing. Industrial research and development will emphasize new products and new methods of application. Research in the U.S. Department of Agriculture will place more emphasis on nonchemical methods of pest control.

Almost certainly, output of pesticidal materials will increase. Many signs point to an expanding demand for pesticides. Agricultural use of pesticides has grown rapidly; farm expenditures for pesticides rose from $292 million in 1960 to an estimated $514 million in 1964, an average increase of 15 percent a year (1). Changing weather and occasional pest infestations may cause shifts in local demands, but these probably will affect national trends only slightly for several years.

The distribution systems for pesticides and other farm inputs complement each other. Retail outlets, in the local areas they service, can offer farmers a complete package of production supplies fitted specifically to their needs. More full-service outlets may be emerging as a major factor in the marketing system for farm supplies.

The business of supplying pesticides lends itself to integration with the operation of a retail outlet. Often, the same warehouse facilities and handling equipment can be used for other farm supplies. Pesticides and fertilizers can be mixed where chemically compatible, a relatively new procedure which may grow in importance. The innovation is likely to be promoted by bulk fertilizer blenders and liquid fertilizer mixers, as these local businesses are already equipped to provide "prescription" service (2).

The increasing use of herbicides has strengthened the total demand for pesticides. Shortages in farm labor coupled with high costs of operation stimulate a demand for chemicals that can reduce labor costs of cultivation and harvesting. An outstanding example of this demand is the large increase in use of herbicides on corn. Between 1959 and 1962, acreage of corn treated with herbicides increased 5 million acres or about 25 percent (9, 14). In the following 3 years, the acreage treated nearly doubled. Most of the additional acres were treated with pre-emergence sprays. In 1965, about 120 million acres of all crops were treated with herbicides at an applied cost of $463 million, 9/ compared with 53 million acres and $129 million in 1959, an increase of 126 percent in acres and 260 percent in expenditures.

Use of insecticides is likely to continue upward but at a slower rate than that of herbicides. A rate of increase of 2 to 5 percent a year may be realistic. Use of insecticides, unlike that of herbicides, is at a relatively mature, or stablized, level. As a consequence, demand for insecticides responds more to growth of population and consumer income than to discovery of new materials and changing technologies. For example, some arsenicals have been used since before the turn of the century and are still effective insecticides. The use of newly developed systemic insecticides will probably increase, but this is likely to be offset by a decline in use of other insecticides.

Little change has occurred in use of fungicides during recent years. Present levels of consumption will probably be maintained.

Prices for pesticides have had varied trends in the past and are likely to do so in the future. Prices of some widely used materials, such as 2,4-D and DDT, decreased as the supply increased to meet demand. On the other hand, 1965 prices of aldrin, chlordane, dieldrin, endrin, malathion, and others were the same as or higher than they were 5 years earlier. Prices of some of these newer pesticides may decrease at the manufacturer's level as supply increases. More price competition is likely at the local level as custom applicators vie for business.

9/ Unpublished estimates, Farm Production Economics Division, ERS.

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NOTE 5--LIVESTOCK FEEDS

by

George C. Allen and Earl F. Hodges 1/

The Setting for the Livestock-Feed Industry

The feed industry differs significantly from other major farm supply industries in that its raw material is farm-produced. In addition, a considerable part of this feed is consumed either on the farm where it is produced or on farms not far away. The portion of feed manufactured in a separate nonfarm industry, however, has been growing in volume and in economic significance. The setting for livestock feeds, therefore, covers a broad and varied spectrum of economic activity. We can best begin by taking a brief look at feed consumption as a whole (2). 2/

Feed Consumption

Consumption of feed by livestock and poultry in the United States increased about 37 percent from 1940 to 1966 (table 1). During this time, the share of the total feed consumed by beef cattle increased from 22 to 44 percent, and that fed to poultry rose slightly from 9 to 12 percent (table 2). The percentages of total feed consumed by other major classes of livestock declined.

While feed consumption rose, feed concentrates increased in relative importance and pasture decreased. Of the total quantity fed in 1966, concentrates made up about 47 percent, harvested roughages 19 percent, and pasture 34 percent. The corresponding percentages in 1940 were 40, 20, and 40, respectively.

The demand for livestock feeds is derived from the demand for livestock and livestock products. The total consumption of all livestock products has risen over the years with increasing population and changes in per capita consumption. For example, per capita consumption of beef and veal has risen while consumption of lamb, mutton, and pork has fallen. Consumption of poultry meat per capita has increased steadily in the last three decades and now amounts to nearly 20 percent of total per capita meat consumption. Per capita consumption of eggs and of dairy products as a group has declined.

These shifts in consumer preferences have a decided impact upon the feed industry. Much of the production of poultry is closely coordinated with hatcheries, poultry processing firms, and regionally and nationally identified feed companies. These firms are interrelated in a variety of ways. Nearly all broilers are now produced under some integrated or contractual arrangement. Perhaps 90 percent of the turkeys

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1/ George C. Allen and Earl F. Hodges are members of the Production Resources Branch, Farm Production Economics Division, Economic Research Service.

2/ Underscored numbers in parentheses refer to Selected References, page 64.

Table 1.--Feed consumed by livestock and poultry, United States, feeding years (beginning October 1) 1940 and 1966 1/

Feed materials 2/	Feed consumption		Percentage change 1940 to 1966
	1940	1966 3/	
	Thousand tons	Thousand tons	Percent
Corn	59,852	92,727	55
Other feed grains	26,271	35,474	35
Byproduct feeds	18,568	43,670	135
Seeds and skim milk	6,304	1,121	-82
Total concentrates	110,995	172,992	56
All hay	37,899	49,869	32
Other harvested roughages	16,931	21,323	26
Pasture	105,833	127,973	21
Total roughages	160,663	199,165	24
Total all feed	271,658	372,157	37

1/ Excludes Alaska and Hawaii.
2/ Measured in feed units (corn equivalents).
3/ Preliminary

Sources: (2,5, and later supplements of 2).

Table 2.--Percentage of total feed consumed by various kinds of livestock and poultry, United States, feeding years (beginning October 1) 1940 and 1966 1/

Kind of livestock	Percentage of total feed consumption	
	1940	1966
	Percent	Percent
Dairy cattle	29.8	22.4
Beef cattle	22.0	43.7
Sheep and goats	8.6	2.8
Poultry	9.0	11.7
Hogs	16.7	15.0
Horses and mules	12.6	1.9
Other livestock	1.3	2.5
All livestock and poultry	100.0	100.0

1/ Excludes Alaska and Hawaii.

Sources: (2,5, and later supplements of 2).

are fed under some form of extended credit program sponsored and backed by a feed or processing company. The growth of commercial cattle feedlots has influenced the use of feed by beef cattle. Custom feeding operations are a factor in this phenomenal growth.

Structure of the Feed Manufacturing Industry

Before World War I, the commercial feed industry was small, concerned mostly with moving surplus feed grains to deficit areas, and marketing the byproduct feeds of the milling industry. Only after nutrition research did the value of formula rations become generally evident to livestock feeders. Other changes in livestock technology began to provide a growing market for mixed rations containing minerals, vitamins, antibiotics, and various other microingredients.

Since World War II, the growth of feed manufacturing has been especially rapid. From 1950 to 1965, it is estimated that the percentage of the four principal feed grains moving through commercial channels increased from 40 to 60 percent. If byproduct feeds are included, about 70 percent of all concentrates moved in commercial channels in 1965. Although information is incomplete, it is estimated that perhaps two-thirds of all concentrates moving in commercial channels entered formula rations, or mixed concentrate feeds.

Because of the special structural characteristics of the feed industry, census data on the prepared animal feeds industry give a less-than-complete picture of feed manufacturing. The Census of Manufactures, for example, classifies manufacturing firms by major activity. Some feed manufacturing may represent a minor supplementary activity for a firm with major interests elsewhere. Information is also lacking on feed formulation within farm operations such as commercial cattle feedlots and integrated broiler concerns. Despite these problems much can be learned about trends and characteristics in the feed industry from the census data.

Growth of the industry has been especially rapid since 1939. Value of shipments of prepared animal feeds in 1963 was nearly 10 times as much as in 1939 (table 3). The number of firms has increased only slightly since 1954, yet in 1963, average value of shipments per employee was $70,164 compared with $38,298 in 1947. The higher ratio of technical, administrative, and field-contact personnel to in-plant production workers reflects the more specialized needs of farmers served today. In 1958, 66 percent of all employees were classified as production employees while in 1963 this percentage had declined to 63 with a smaller total number of employees (table 4).

Even though the number of firms has increased since 1954, total employment has declined. Employee productivity, measured in value of shipments, has increased about 5 percent a year since 1954. One of the problems feed companies face is automation, which has come rapidly, and with many innovations. Many plants that were considered "industry standard" in 1955 are obsolete by current models. Not only have in-plant material-flow systems changed, but some of the industries these systems were built to serve have moved to other areas of surplus rural labor and lower production costs.

Table 3.--Prepared animal feeds industry: Number of firms, employees, value added, and value of shipments, United States, selected census years 1/

Year	Number of firms	Employees		Value added	Value of shipments
		Total	Production		
	Number	Number	Number	Thous. dols.	Thous. dols.
1935	942	15,427	11,606	58,040	288,662
1939	1,383	24,177	15,401	99,240	401,880
1947	2,688	55,152	40,115	393,049	2,112,241
1954	2,292	59,890	41,290	584,135	2,702,267
1958	2,379	57,313	38,010	798,892	3,238,414
1963 2/	2,587	55,061	34,853	919,604	3,863,320

1/ Excludes Alaska and Hawaii.
2/ Preliminary. Latest year for which these data are available.

Source: (7).

Table 4.--Prepared animal feed industry: Number of firms and employees by regions, United States, 1958 and 1963 1/

Region	Firms		Total employees		Production workers	
	1958	1963	1958	1963	1958	1963
Northeast	48	56	1,695	1,450	1,266	1,054
Middle Atlantic	254	257	6,984	5,806	4,751	3,907
East North Central	373	382	10,176	9,802	6,835	6,496
West North Central	516	575	11,647	11,902	7,076	6,714
South Atlantic	353	405	8,247	7,285	5,551	4,638
East South Central	192	211	5,583	5,260	3,847	3,446
West South Central	264	290	5,839	6,472	3,804	4,091
Mountain	115	142	1,686	2,051	1,244	1,385
Pacific	264	269	5,456	5,033	3,636	3,122
United States	2,379	2,587	57,313	55,061	38,010	34,853

1/ Excludes Alaska and Hawaii.

Source: (7).

Geographic Shifts and Farm Size

From 1958 to 1963, the number of feed companies increased 9 percent (table 5), but firms employing 20 or more employees decreased. The number of firms employing 20 or more employees declined in the Northeast, Middle Atlantic, and South Atlantic States and increased in other regions. Some of the decreases can be attributed to mergers or other consolidations, but the changes also reflect a shift in areas of concentrated poultry and livestock production. Increased emphasis on feeding poultry and fattening cattle south and west of the Corn Belt has encouraged more feed manufacturing capacity in these areas. Also, many local grain-elevator operators expanded sources of revenue by offering complete milling and grain-bank services to farmers.

The shift of the feed-manufacturing industry to the Southeast and the West is a noteworthy example of decentralization and orientation toward demand. Early industry location was oriented toward flour mills, elevators, terminal markets, and feed-grain surplus areas. Feed mills located in terminal and other key positions in Pennsylvania, Ohio, Illinois, and Missouri mixed much of the formula feed consumed in the northeastern and southeastern States.

Table 5.--Prepared animal feeds industry: Number of firms, by regions, United States, 1958 and 1963 1/

Region	1958		1963		Percentage change 1958 to 1963	
	All firms	20 or more employees	All firms	20 or more employees	All firms	20 or more employees
	Number	Number	Number	Number	Percent	Percent
Northeast	48	25	56	22	17	-12
Middle Atlantic	254	86	257	66	1	-23
East North Central	373	103	382	104	2	1
West North Central	516	130	575	145	11	12
South Atlantic	353	116	405	104	15	-10
East South Central	192	63	211	66	10	5
West South Central	264	91	290	101	10	11
Mountain	115	28	142	30	23	7
Pacific	264	73	269	73	2	0
United States	2,379	715	2,587	711	9	-1

1/ Excludes Alaska and Hawaii.

Source: (7).

Factors mainly responsible for the trend toward decentralization of feed manufacturing plants were (1) demand for bulk feed services and growth of service competition, (2) changes in transportation costs, and (3) growth of demand in new areas. Each of these factors is, in turn, directly dependent on sufficient volume to gain economies of scale. Volume and product control are both needed if regional feed firms and concentrated producing areas are to remain competitive and fully able to exploit marginal profit opportunities.

The earlier demand for manufactured feeds on the part of milk and poultry producers was a widely diffused demand. Much of the new demand has a high geographic density and is generated by cattle feedlots, feed mills, poultry processing plants, individual farmers under some form of contract or integration arrangement, and others operating in specialized areas.

Market Shares

An analysis of the changing structure of firms engaged in the production of commercial feed suggests an evolutionary shift away from elevator and flour businesses to vertically integrated firms in the feed industry. Although feed manufacturing firms are now larger, they are only slightly fewer in number than formerly. And there has been a decrease in the share of the market in the hands of the leading firms. In the mid-1930's, the four largest feed companies accounted for nearly 25 percent of industry shipments. Twenty years later the four largest accounted for 21 percent and the 20 largest feed companies represented only 43 percent of the industry's value of shipments (8). By 1964, the estimated share of the four largest firms had declined further to 17 percent of industry sales and the 20 largest had slightly less than 31 percent of the total reported sales of manufactured feeds (table 6). This is not a great degree of concentration. However, all but five or six of these 20 large firms do business in relatively small geographic areas. The extent of intraregional market penetration for these respective firms is not well known, and it may be that farmers in some areas have relatively limited choices.

Changing Structure

To achieve its basic objectives, each feed company tries to foresee and adapt itself to changing conditions. Some firms--such as Central Soya, Nutrena Mills, and Ralston Purina--retain terminal market locations yet recognize the need for decentralization. With the concept of neighborhood mill sites serving specialized types of farming, these firms have, in part, decentralized their milling operations to identify their feed businesses with the major livestock or poultry enterprise of a given area. To extend the productive life of existing large, terminal feed mills, these companies have also developed bulk distribution systems which incorporate outlying relay depots supplied by rail hopper cars and automated bulk handling systems. Such bulk distribution innovations improve the efficiency and competitive position of terminal mills. However, even these innovations may not be sufficient to offset outmoded material-handling procedures within the plants themselves. To renovate and modernize an old manufacturing facility is often more costly than to build a completely new and modern plant.

Some firms emphasize mixing and sale of complete feeds; others, supplements and concentrates. Many larger mills in the Corn Belt produce relatively high-analysis protein feeds, or pre-mixes. These are then "cut" with the addition of grains by the

Table 6.--The 20 largest feed manufacturing firms ranked by estimated tons sold and share of reported total manufactured feeds, United States, 1964 1/

Rank	Firm	Estimated sales, 1964	Percentage of total sales
		Million tons	Percent
1	Ralston Purina	9.6	17
2	Agway, Inc.		
3	Central Soya		
4	Nutrena Mills		
5	Cooperative Mills, Inc.	8.0	14
6	Allied Mills		
7	Albers Milling Co.		
8	Quaker Oats		
9	Textron (Beacon Feeds)		
10	Hales and Hunter		
11	Missouri Farmers Assoc.		
12	Consumer Cooperative Assoc.		
13	Pacific Growers, Inc.		
14	Wirthmore Feed Inc.		
15	Western Farmers Assoc.		
16	Hubbard Milling Co.		
17	Moorman Feed Co.		
18	John W. Eshelman and Sons		
19	F.S. Services, Inc.		
20	Walnut Grove Feed Co.		
21	All others	39.7	69
	All manufactured feed	57.3	100

1/ Excludes Alaska and Hawaii.

Source: Estimates prepared in Farm Production Economics Division, ERS.

local feeder or by a custom grinding and mixing retail service center. This type of arrangement could be classified as a form of decentralization since the high-protein manufactured feeds must be further processed with locally produced grain before they are fed.

As noted above, many firms have decentralized their mills in grain-deficit areas, particularly where conditions have encouraged the development of an expanded livestock industry. In many of the recent broiler- and egg-producing areas of the South, local retailers have erected feed mills which compete with larger firms that initially brought the new industry to a specific area. Decentralization in the feed industry has been accomplished by the satellization of milling facilities which are centrally controlled, and by increasing the number of small local establishments. Many successful local feed firms have become, through merger, acquisition, or consolidation, a part of a larger regional or national company with diversified interests.

How lasting the gains in efficiency from improvements in methods of distribution will be is not yet known. Such changes as feed depots and satellite mills are now being tried throughout the industry. Basic changes in the farming patterns of a given area also have a profound impact on the feed industry. The recent rise of the poultry and livestock industry in the Southeast is a classic example.

Farmer Cooperatives in the Feed Industry

Farmer cooperatives have made an important contribution to the feed industry. In the last two decades, they have handled about 20 percent of the commercial formula feed business in the United States (1), besides contributing much to innovations and improvements in services and increasing competition.

Feed Retailing

Competition among retail feed outlets is sometimes keener than competition among their feed suppliers. A retailer competes not only with other retail firms for the farmer's business but also with feed manufacturers selling directly to farmers (fig. 1). Usually a farmer, to qualify for direct mill procurement, must use a large volume of feed. To offset this potential loss of business, many retailers provide added services--from seed cleaning, grain banks, and marketing service to complete, "one-stop" service. In many instances, today's feed retailer is multiple-franchised and offers competing brands of feed.

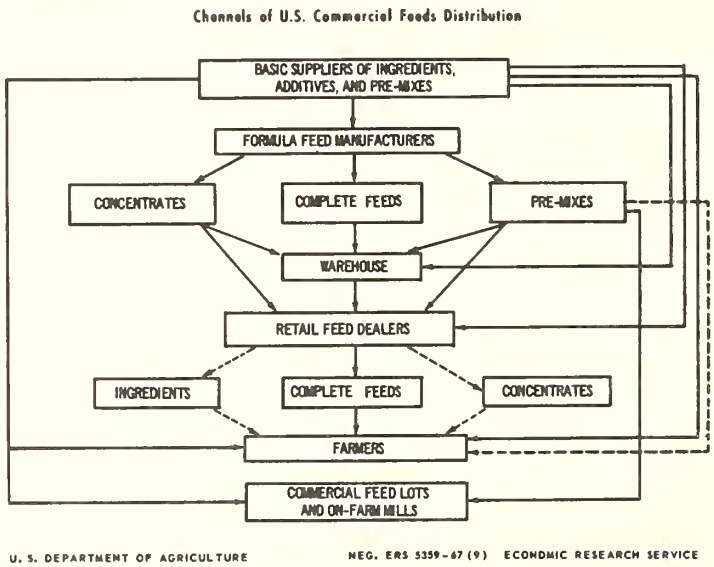

Figure 1

Most farm retail stores are locally owned. As a private operator, the retailer determines his own markups, credit policies, inventories, and customer services. He also chooses various lines of farm production supplies. With strong competition and with fewer farmers, many farm stores have moved into the building supply business. Others have begun distributing petroleum products, fertilizer, and pesticides. Farm supply items are often but a minor part of the store's total dollar volume.

Looking Ahead

Many changes lie ahead in the feed industry. Some are related to increases in livestock production and some to innovations in feed technology and organization. Forces seem to be working, on the one hand, toward greater use of commercial formula feeds and on the other, toward more on-farm milling and mixing. Large commercial cattle feedlots and large broiler operations formulate rations as an integral part of their total business. Relatively efficient feed grinding and mixing installations are now available even for moderate-sized commercial livestock farms. In the 5 years from 1961 to 1965, nearly 115,000 farm-size feed mills and power grinders were sold. About half were combination grinder-mixers. How many were bought by commercial feedlots and how many by other farmers is not known.

On the other hand, the development of new micronutrients and feed additives that require careful handling may give specialized feed manufacturers special advantages. Developments in the protein field are suggestive. The current increase in the use of urea to supplement protein is one example. The potential development of high-protein corn is another. Perhaps even more significant in the future will be the use of synthetic amino acids. Protein from algae grown on petroleum or waste products may eventually be still another source of low-cost protein.

Several current buying practices by farmers are likely to have a growing impact on the feed industry. One of the more significant is a practice first used by the farmer cooperatives of early days. Local groups of farmers pool their orders and buy production supplies in large quantities direct from manufacturers. A recent study by Mutti at Illinois shows that considerable success was achieved by such pooled-order groups (6). This practice may spread.

As farms become larger and fewer in numbers and greater emphasis is placed on least-cost feed formulation, any extras for which added costs cannot be justified will be dropped. In an effort to reduce production costs, commercial farmers may bargain with feed suppliers for a season's feed requirements on the basis of ingredient cost plus a processing fee. This kind of arrangement is used in the Los Angeles milkshed and will probably be tried elsewhere.

The feed industry by the end of this century will probably be more consumer oriented. The industry, through coordinated arrangements with livestock farmers and processors, will move closer to producing what the consumer wants, when and where he wants it, and probably at more uniform price levels.

Broiler "factories" of several million birds completely controlled and integrated with a national feed supply company may not be uncommon. A similar pattern may also develop for egg and turkey production. Beef finishing companies with capacities exceeding 100,000 head may become commonplace in the cattle feeding business.

Milksheds may no longer be confined to a relatively small radius surrounding a particular metropolitan area. A more closely coordinated animal agriculture may mean a smaller number of feed manufacturers with integrated operations and operating margins considerably lower than those of today.

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NOTE 6--FARM CREDIT

by
Philip T. Allen 1/

The Institutional Setting

The extension and acceptance of credit is one of the Nation's largest industries. Credit is a way by which farm operators obtain the use of farming resources and one of several ways of bringing resources into productive combinations. The supplying of farm credit--exceeding $45 billion at the beginning of 1967--is a major activity of many financial institutions, and an important activity of many other firms and individuals.

Farmers also use large amounts of leased capital. Of the approximately $270 billion of physical and financial assets indicated by the Balance Sheet of Agriculture for January 1, 1967, (4)2/ an estimated $80 billion was leased.3/ Most of the leased capital is farmland, much of which is leased from "nonfarm" landlords outside the farm sector. But part--close to a tenth--is owned by farm operators who lease it to other farm operators.

A third way of obtaining the use of farming resources is not considered to be credit or leasing in the usual sense. This is the provision of such capital resources to farmers by "contractors," a method that is apparently becoming increasingly important.

Real-Estate and Non-Real-Estate Credit

Farm credit is commonly divided into real-estate credit in which debt is secured by farmland and buildings, and non-real-estate credit in which debt is secured by other than real property or is not secured by pledging any specific assets. These security classifications do not always indicate the purposes of the loans. A substantial and growing portion of real-estate credit is used to finance expenditures for such intermediate-term items as livestock and machinery. However, most non-real-estate credit is used for financing non-real-estate purchases.

1/ Philip T. Allen is a member of the Agricultural Finance Branch, Farm Production Economics Division, Economic Research Service.

2/ Underscored numbers in parentheses refer to Selected References, page 75.

3/ Informal estimate of leased capital made by the writer.

The Structure of the Credit Business

Farmers obtain loan funds, or their equivalent, from two groups of creditors. One group is made up of the financial institutions specifically in the moneylending business. The other consists of a broad spectrum of individuals, merchants, and dealers. Many merchants and dealers extend credit to promote sales of the goods they handle. Machinery dealers are a good example. Here, the interest return on the loan may be of less concern to the seller than the sale of his product.

Figure 1, a flow chart, shows sources from which farmers borrow, and those from which lenders obtain their loanable funds (in addition to their own resources). Table 1 indicates the relative importance of each source.

The January 1 date slightly obscures the true short-term debt situation of farmers. Such debt, rising slowly in late winter and early spring, usually peaks in the summer. Thus, January 1 data tend to understate short-term credit. The flexible nature of short-term credit is indicated in the following tabulation that shows the amount of farm production loans outstanding for the production credit associations and the commercial banks on the indicated dates (2, 4). Part of the rise from January to June is credit growth, and part of the increase reflects seasonal rise in use of funds.

	Short-term loans outstanding (million dollars)
January 1, 1965	$ 9,253
June 30, 1965	10,372
January 1, 1966	10,243
June 30, 1966	11,598
January 1, 1967	11,537

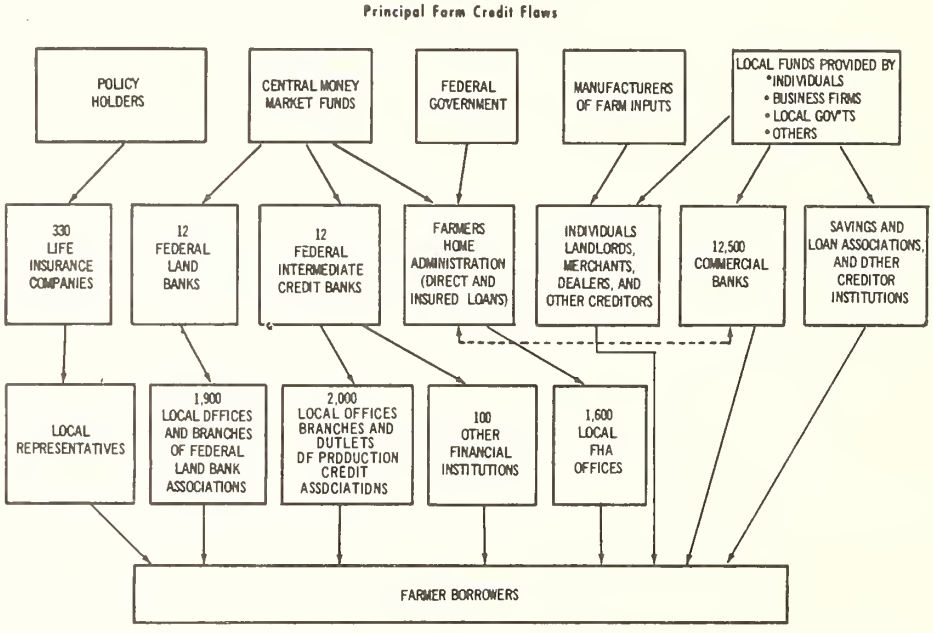

Figure 1

Table 1.--Farm debt outstanding, Jan. 1, 1967, by lender, United States 1/

Lender	Amount	Distribution
	Million dollars	Percent
Real estate debt:		
Life insurance companies	5,211	12
Federal land banks	4,908	11
All operating banks 2/	3,164	7
Farmers Home Administration (direct loans)	582	1
Individuals, merchants and dealers, and others 3/	9,418	21
Total	23,283	52
Non-real-estate debt:		
All operating banks 2/	8,521	19
Production credit associations	3,016	7
Farmers Home Administration	735	2
Federal intermediate credit banks 4/	157	5/
Merchants and dealers, individuals, and others	8,820	20
Total	21,249	48
All debt (excluding Commodity Credit Corporation loans)	44,532	100

1/ Excludes Alaska and Hawaii.
2/ Includes mutual savings banks as well as commercial banks.
3/ Includes all lender and lender groups that do not periodically report their holdings of farm loans (sometimes termed "nonreporting lenders").
4/ Loans and discounts of the Federal intermediate credit banks to other than the production credit associations.
5/ Less than 0.5 percent.

Source: (4).

Financial institutions mainly sell the use of money. Interest returns are typically modest and do not permit lenders to take long chances and still stay in business. As a group, they are low-risk lenders. In contrast, sellers of goods or services may make higher risk loans because usually their returns also include profits from sales as well as interest. This group is characterized as medium- or high-risk lenders.

Private, Cooperative, and Governmental Credit Sources

Much of the credit for farmers is provided from private sources. Life insurance companies, commercial banks, and individuals provide about 70 percent of all real-estate mortgage credit. On the non-real-estate side, some 80 percent of all credit is from banks, merchants, and individuals.

The Farmers Home Administration, an agency of the Federal Government, makes loans to farmers who are unable to obtain adequate financing from other sources. The agency makes direct non-real-estate loans, and both direct and insured real-estate loans. The insured credit is like direct FHA loans, except that the funds are supplied by private sources with no risk of loss to the supplier of the funds. The outstanding volume of these insured loans to farmers on January 1, 1967, was about $1,040 million, about three-fourths greater than the volume of direct real-estate loans as shown in table 1.

The Federal land banks and the Federal intermediate credit banks--key elements of the cooperative Farm Credit System--are significant credit sources in the real-estate and non-real-estate areas respectively. These two credit sources have a major advantage over many local commercial banks in that they have ready access to central money markets for loanable funds. Local units of these agencies are farmer cooperatives.

Loan funds are borrowed jointly by the banks within each bank system in the Farm Credit System. Many of the procedures and operating methods used within each bank system are similar throughout the Nation. One of the System's important characteristics is its ability to adapt to change. Methods of operation that seem promising in one part of the organization appear to be promptly appraised and, if deemed worthwhile, put in use by other parts of the organization.

Commercial banks can draw funds from broader areas under some types of banking systems, and, under the unit banking system, can obtain outside funds from their correspondent banks. Little is known about the extent of such arrangements with correspondent banks. A survey in 1966 by the Federal Reserve System indicated that only 5 percent of outstanding farm loans held by commercial banks were held jointly by two or more banks in a sharing arrangement.

Table 1 includes only farm debt owed directly to lenders by individual farm operators and landlords. Credit to farmers is also supplied indirectly through other sources, especially some cooperatives. Important parts of the Farm Credit System are the 12 district cooperative banks which, together with the Central Cooperative bank, provide fixed and operating credit to farmer cooperatives. Rural electric and telephone cooperatives, under provisions of the Rural Electrification Act, obtain Federal loans to finance construction of their facilities.

Installment Contract Sales by Individuals

Individuals are an important source of real-estate credit. Many of these are farmers who sell their farms on retiring. They ordinarily provide their own funds for such financing, represented by their equity in land they are selling. In recent years, this equity has been increased considerably by rising land prices. Sales are often made under a land contract in which the downpayment may vary from nothing to usually no more than 30 percent of the purchase price. Title to the land is retained by the seller until a certain part of the total purchase price agreed upon has been paid. There is often an income tax advantage to the seller (under either a land contract or a mortgage) if the downpayment does not exceed 30 percent.

The chief interest of such a seller is in a favorable sale price for his farm, and in any income tax considerations. If the seller is acquainted with the buyer, the seller may have a good basis for a judgment of the buyer's ability to meet his debt obligations. Individuals can be thought of as financing the part of the farming operations that is too high a risk for most institutional lenders.

After a land contract has run for some years, it is often refinanced with an institutional lender. By then the buyer has usually been able to increase his assets, land prices may have risen, and his equity position may be acceptable for a conventional mortgage loan.

Merchant and Dealer Credit

Credit for its farmer customers has long been recognized as an essential part of a successful retailing operation. To supplement local credit sources, many firms in the major farm supply industries have their own credit affiliates or have working arrangements with independent financing organizations.

The financing of "hard goods" such as farm machinery and of "soft goods" such as fertilizer or feeds shows a number of contrasts. Farm machinery has a typical productive life of several years, while fertilizer contributes to output primarily for a single year. The outlay for a major piece of equipment usually represents a much larger initial investment. Debt for such a machinery purchase may be repaid in installments extending over several years, while the fertilizer debt customarily is repaid from the income of the single year. Another difference is that the machine is a tangible piece of property that the borrower knows may be repossessed if he does not pay his loan. It may be less clear to the borrower that he is equally liable for his fertilizer bill.

Because of such differences, credit experiences differ between suppliers dealing with perishable inputs and those dealing with durable inputs. Suppliers of perishable inputs have not developed as extensive credit operations as those worked out for farm machinery. Moreover, some local lenders may not recognize the contribution that fertilizer can make to farm output and may be reluctant to finance the purchase of as much fertilizer as would be economically desirable. Better arrangements for financing fertilizer and other inputs could merge the specialized production knowledge of the supplier and his desire to sell products with the specialized financial knowledge of a local lender.

The financing of farm machinery has been well developed in recent years. Most manufacturers of farm machinery, through their dealers, have financing plans available for farmer customers with either a bank or other local credit institution. But often they are with a company-affiliated or nonaffiliated financing organization that draws on outside sources for loan funds. One estimate indicates that the volume of credit extended to farmers by a group of these central credit organizations more than doubled from 1963 to 1966 (3). This was considerably greater than the increase in farm machinery sales in the same period.

Despite rapid growth of farm debt in recent years, there has been relatively little shifting of position of the various lenders (table 2). The cooperative Farm Credit System has increased slightly in importance since 1955. Federal land banks are below their pre-World War II position when they held an exceptionally large proportion of farm real-estate loans as a result of their extensive refinancing and takeover of debt during the crisis years of the 1930's. Production credit associations have been vigorous lenders in recent years and have gained relative to commercial banks in the non-real-estate area.

There has been no apparent shift toward greater importance of noninstitutional lenders. Established lenders, by adapting their policies and operations to changing needs, seem to have maintained their relative positions in the total farm credit market.

Trends in Farm Credit Use

Major reasons for marked expansion in farm debt in recent decades, and particularly since 1960, include (1) desires of farmers to increase their incomes; (2) development of new machines and other technological improvements encouraging enlarged operations; (3) substitution of capital equipment for labor; and (4) willingness of creditors and firms that do leasing to provide part of the capital.

> Viewed broadly, the sharp increase in farm debt since World War II has been one of the factors required to bring about the great changes that have occurred in our agriculture. In that period, there has been an unusually great advance in agricultural technology and in the resulting yields and outputs; a marked shift from farm tenancy to part-ownership of farms; a notable increase in the number of larger farms; and a sharp decline in the number of smaller farms (5, p. 12).

Some individuals have been of the opinion that the growth in debt was an indication that the financial condition of farmers was deteriorating. They reasoned that since aggregate farm income had not increased much, the growth in debt reflected expenditures by farmers beyond their incomes--that out-of-pocket expenditures and living expenses were too great in relation to earnings, and that many farmers would ultimately be forced out of business. It was pointed out, also, that sharp rises were occurring in prices of farmland, and that these increases were not necessarily accompanied by increases in earnings from land; thus, debts of some purchasers of land were becoming harder to repay.

Table 2.--Holders of farm debt, United States, Jan. 1, 1940, 1955, 1967

Lender	Distribution		
	1940	1955	1967
	Percent	Percent	Percent
Real-estate debt:			
Life insurance companies	10	13	12
Federal land banks 1/	29	8	11
All operating banks	6	8	7
Farmers Home Administration (direct loans)	2/	2	1
Individuals, merchants and dealers, and others 3/	24	22	21
Total	69	53	52
Non-real-estate debt:			
All operating banks	9	19	19
Production credit associations	2	4	6
Farmers Home Administration	4	3	2
Federal intermediate credit banks 4/	2/	2/	2/
Merchants and dealers, individuals, and others 3/	16	21	20
Total	31	47	48
All debt (excluding Commodity Credit Corporation loans)	100	100	100

1/ Includes Federal Farm Mortgage Corporation.
2/ Less than 0.5 percent.
3/ Includes all lender and lender groups that do not report holdings of farm loans, sometimes termed "nonreporting creditors."
4/ Loans and discounts of the Federal intermediate credit banks to other than the production credit associations.

Source: (4).

Analysis of available data suggests that only a few farmers borrowed excessively and that most profited by their use of credit. If two small debt-free farms with low earnings are consolidated into a single larger farm, the operator of the expanded unit may have acquired a substantial debt. However, providing the rental or purchase price of the land bears a reasonable relation to its earnings, the operator of the new unit is likely to be able to carry the debt and provide a more adequate living for his family than could have been provided on one of the smaller farms. Much of the recent growth of borrowing probably is associated with enlargement of farming operations as well as with other types of improvement in farming.

Farm Income and Debt Payments

Farm debt has sometimes been compared with "realized net farm income" of farm operators as calculated by the U.S. Department of Agriculture. Valid conclusions from such comparisons are difficult to draw, even though the trend of realized net farm income does reflect changes in the farm economic situation. The reason is that agriculture is not a single entity. The farm debt situation is determined by the circumstances of the individuals who owe the debts, not by the circumstances of farmers in general.

In addition, there are technical reasons why the comparison of farm debt and realized net farm income has limited significance. For one thing, realized net farm income does not include the large amount of income that farmers receive from off-farm sources.

Beyond that, farmers do not set aside and immediately reinvest cash income exactly equal to allowances for capital depletion made in computing realized net farm income. Instead, they follow the more flexible policy of adjusting crop inventories, buying livestock and equipment, and improving or constructing buildings as needed or as their circumstances permit. These investments are made in amounts that often exceed, but may be less than, the amounts necessary to cover depletion of capital. At times, they use income needed to replace capital depletion for living expenses or to pay debts.

Thus, funds that farmers have available for living expenses, debt payment, and cash purchases of capital assets (including those needed to maintain as well as to increase their capital assets) are the sum of net farm income before inventory adjustment, off-farm income of farmers, and depreciation and other capital consumption allowances that were deducted in computing net farm income. When farm debt is compared with this more realistic amount, the debt appears much smaller than when it is compared with realized net farm income.

Estimates indicate that farmers as a group had substantial cash savings over debt payments in 1961 (the latest year for which such estimates are available). These cash savings were reinvested in maintaining and building up the farm plant.4/ Operators of farms from which gross product sales were $10,000 or more, even though they included only a fourth of the farmers, apparently had substantially larger savings

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4/ Estimates made in the Agricultural Finance Branch, Farm Production Economics Division, ERS.

than the much greater number of operators of smaller farms. After providing for maintenance of existing assets, larger farmers had nearly $3 billion of their total incomes of about $9 billion available for repaying long-term capital debts, or for increasing their assets. The great bulk of farm debt is owed by operators of larger farms. Farmers with product sales of under $10,000 had practically no funds left to invest in their farms after their family living expenses had been paid.

Many private lenders, such as banks and life insurance companies, have expanded both their farm lending and their professional staffs that work with farmers. The number of commercial banks that employ trained agricultural representatives has continued to grow. The cooperative Farm Credit System has developed into a large-scale operation, largely independent of Federal Government financial support. Merchants and individuals (mostly sellers of farms) have provided large amounts of credit to farmers. Most farmers have several sources from which to pick the lender or lenders best suited to their needs.

A reassuring aspect of the growth in farm debt in recent years has been the maintained position of the long-established lenders. Much of total farm debt is still held by lenders who have a great deal of experience in farm financial matters.

Looking Ahead

Supplies of real estate and production loan funds for farming will need to expand significantly in the years ahead as farmers step up production to meet increasing domestic and foreign needs. The numbers of farms and farmworkers are likely to continue to decline, and the size, efficiency, and incomes of individual farm units to rise. A growing volume of credit will be needed to help finance the increasing fixed capital investments on these larger units. Loan funds for short- and intermediate-term purposes will increase as farmers buy larger and larger quantities of many production inputs. Fluctuations in amounts of loan funds and costs of their use will occur from time to time but the strong upward trend in farm credit use of recent years is likely to go on.

Loans for farm real-estate purchases will be influenced by future trends in technology and in prices buyers are willing to pay for farm real estate. As the number of farms continues to diminish, as is expected, the number of transfers will taper off. However, the size of individual farm real-estate loans will probably rise sharply under the twofold impact of increasing land prices and larger acreages per farm. Appraised values and sizes of loans set by lenders are expected to continue upward.

The largest single supply of loan funds, or their equivalent, for real-estate purchases comes from the sellers. Close to 40 percent of the number and 45 percent of the dollar volume of all credit purchases currently are seller financed either by installment sale contracts or by purchase money mortgages. In either instance, the seller supplies the equivalent of loan funds for the transfer when he accepts the credit of the buyer.

Downpayments on such land purchases are usually smaller and the amounts financed larger than on loans made by institutional lenders. Large amounts of seller financing will continue in the future. Experience has been favorable, buyers are likely to need financing, and sellers will probably have financial resources which will permit them to provide financing.

The supply of non-real-estate loan funds is expected to advance in the foreseeable future. Increases are probable in availability of all types of such funds--intermediate-term, short-term, and open-account debt. Trends in the use of farm production loans will closely follow farmers' purchases of feeder cattle, of machinery and equipment, and of other industrially produced farm inputs. Quantities purchased and unit prices are both expected to increase.

As bundles of capital required for commercial farms grow both in size and complexity, farmers will need to devote more attention to financial management. Internal generation of funds may account for a smaller part of total annual capital needs. A major influence will be the proportion of net farm earnings that farmers, themselves, are willing to reinvest in their farms. The estimate of incomes and investments of farmers in 1961, cited earlier, indicated that farmers with gross values of sales of $10,000 or more may be saving and reinvesting nearly a third of their net earnings in their farms. If farmers should reduce their rates of saving to rates more like those of other groups in the economy, this would place greater demands on credit markets. Good credit management will become an increasingly important and more distinct part of the farm business.

Problems of financing will generate changes in lending systems. As sizes of loans increase and the total amount loaned rises, lenders will seek to develop improved methods of meeting farmers' needs for loans. Examples of the kinds of arrangements that may be developed for providing capital to farmers are: one-stop lending devices, family corporations, additional sources of high ratio debt-to-assets financing, contractual agreements, and improved leasing arrangements.

Few estimates of future use of credit by farmers have been made. One set by John Brake of Michigan State University for the 14-year period from 1966 to 1980 is shown in table 3.

This estimate implies a somewhat slower rate of increase in credit use, particularly for non-real-estate credit, during the 1966-80 period than occurred in the preceding 14 years. In dollar amounts, the projected increases in both real-estate and non-real-estate debt are greater than those from 1952 to 1966.

Estimates of prospective farm credit needs are helpful in developing public farm credit policies and are useful to lenders in their efforts to devise improved sources of loan funds and mechanisms for making loans. In the future, greater attention needs to be given to studying factors related to credit use by farmers, and to preparing estimates of prospective use of credit.

Table 3.--Farm debt outstanding January 1, United States, 1952-66, and estimated 1980

Type of debt	Actual		Estimate	Percentage increase	
	1952	1966	1980	1952 to 1966	1966 to 1980
	Billion dollars	Billion dollars	Billion dollars	Percent	Percent
Real-estate debt	6.7	21.2	59	216	178
Non-real-estate debt (including CCC loans)	8.0	20.4	41	155	101
Total debt	14.7	41.6	100	183	140

Source: Adapted from (1).

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